This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

For additional copies of this report, write to:

Bonneville Power Administration
Public Information Office - ALP-22
P.O. Box 3621
Portland, OR 97208

Please include title, author, and DOE/BP number from back cover in the request.

SMOLT MONITORING AT THE HEAD OF LOWER GRANITE RESERVOIR AND LOWER GRANITE DAM

ANNUAL REPORT 1992

Prepared by:

Edwin W. Buettner, Senior Fishery Research Biologist
Arnold F. Brimmer, Senior Fishery Technician

Idaho Department of Fish and Game
Boise, ID 83707

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number **83-323B**
Contract Number **DE-BI79-83BP11631**

NOVEMBER 1993

TABLE OF CONTENTS

CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

ABSTRACT

This project monitored the daily passage of chinook salmon Cncorhvnchus tshawvtscha and steelhead trout O. mvkiss smolts during the 1992 spring outmigration at migrant traps on the Snake River and the Clearwater River.

Annual chinook salmon catch at the Snake River trap was the second lowest since the beginning of this project. The low trap catch was due to extremely poor trap efficiency associated with severe low flows. Hatchery steelhead trout catch was similar to 1988 through 1991. Wild steelhead trout catch was 35% less than in 1991. Operations at the Snake River trap and a new screw trap were extended through the end of July to collect summer-migrating age-0 chinook. The differentiation of age-0 chinook from spring and summer chinook (age-l) using physical characteristics was again employed in 1992. The Snake River trap and the screw trap collected 20 and 18 age-0 chinook salmon, respectively, due to extremely low discharge.

Chinook salmon catch at the Clearwater River trap was the highest since trap operation began in 1984. Hatchery steelhead trout trap catch was 23% lower than in 1991. Wild steelhead trout trap catch was the highest since trap operation began.

Fish tagged with Passive Integrated Transponder (PIT) tags at the Snake River trap were interrogated at three dams with PIT-tag detection systems (Lower Granite, Little Goose, and McNary dams). Cumulative interrogation at the three dams, for fish marked at the Snake River trap, was not calculated for chinook salmon due to a lack of data over the entire migration season. The rates for hatchery steelhead trout and wild steelhead trout were 44.9% and 72.9%, respectively. Cumulative interrogation at the three dams for fish PIT-tagged at the Clearwater River trap was 55.1% for chinook salmon, 60.4% for hatchery steelhead trout, and 73.1% for wild steelhead trout. Cumulative interrogations for hatchery steelhead tagged at the Snake River trap and recovered at the downstream dams was about 50% less than in previous years.

Travel time (d) and migration rate (km/d) through Lower Granite Reservoir for PIT-tagged chinook salmon and steelhead trout, marked at the head of the reservoir, were affected by discharge. Statistical analysis showed that a two-fold increase in discharge increased migration rate by 2.1 times for PIT-tagged hatchery steelhead trout released from the Snake River trap. This was considerably slower than in 1991 when they migrated 3.1 times faster with a doubling of discharge. Hatchery steelhead trout marked at the Clearwater River trap migrated 2.3 times faster with a two-fold increase in discharge. A two-fold increase in discharge increased migration rate by two times for PIT-tagged wild steelhead trout released from the Snake River trap and the Clearwater River trap.

Authors:

Edwin W. Buettner
Senior Fishery Research Biologist

Arnold F. Brimmer
Senior Fishery Technician

INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) directed the Northwest Power Planning Council (NWPPC) to develop programs to mitigate for fish and wildlife losses on the Columbia River system resulting from hydroelectric projects. Section 4(h) of the Act explicitly gives the Bonneville Power Administration (EPA) the authority and responsibility to use its resources "to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project on the Columbia River system."

Water storage and regulation for hydroelectric generation severely reduces flows necessary for downstream smolt migration. In response to the fishery agencies' and Indian tribes' recommendations for migration flows, the NWPPC Columbia River Basin Fish and Wildlife Program proposed a "water budget" for augmenting spring flows.

The Northwest Power Planning Council's water budget in the Columbia's Snake River tributary is 1.19 million acre-feet of stored water for use between April 15 and June 15 to enhance the smolt migration. This is the second year since the establishment of the water budget that over a million acre-feet of water were made available. In the past, only about a third of the requested 1.19 million acre-feet has been provided.

To provide information to the Fish Passage Center (FPC) on smolt movement prior to arrival at the lower Snake River reservoirs, the Idaho Department of Fish and Game (IDFG) monitors the daily passage of smolts at the head of Lower Granite Reservoir. This information allows the FPC to request the limited Snake River water budget for optimal use to provide improved passage and migration conditions.

Smolt monitoring is beneficial for water budget management under all flow conditions and becomes critical when low flow conditions reduce migration rates. In years of low flow (drought years), knowledge of when most smolts have left tributaries and entered areas that can be affected by releases of stored water allows managers to make the most timely use of the limited water budget resource. Five low flow years (1987, 1988, 1990, 1991, 1992) have occurred during this smolt monitoring project. The indications are that judicious use of the water budget can enhance the timing and migration rate of juvenile chinook salmon and steelhead trout.

Additionally, the IDFG smolt monitoring project collects other useful data on relative species composition, hatchery steelhead trout vs. wild (natural) steelhead trout ratios, travel time, and migration rate. All age-0 chinook are PIT-tagged (Prentice et al. 1987) to determine migration rate through Lower Granite Reservoir and cumulative interrogation rate. All wild steelhead trout smolts are PIT-tagged to determine timing of wild adult steelhead trout one and two years later as they return to spawn. By monitoring smolt passage at the head of Lower Granite Reservoir and at Lower Granite Dam, migration rates (km/d) under various riverine and reservoir conditions can be estimated and compared. Monitoring sites, on both the Snake and Clearwater arms of Lower Granite Reservoir, permit migration timing to be determined for smolts from each drainage. Although not yet achieved, relative abundance of hatchery and wild stocks of steelhead trout can be determined and used to document wild stock rebuilding progress. This Smolt Monitoring Program's information is complementary to other Snake and Columbia River NWPPC-supported projects.

OBJECTIVES

1. Provide daily trap catch data at the head of Lower Granite Reservoir for water budget and fish transportation management purposes.

2. Determine riverine travel time from the point of release to the smolt traps (index sites) at the upper end of Lower Granite Reservoir for freeze-branded and PIT-tagged smolts.

3. Provide an interrogation site for PIT-tagged smolts, marked on other projects, at the end of their migration in a riverine environment and the beginning of their migration in a reservoir environment.

4. Determine reservoir travel time for spring/summer chinook salmon, age-0 chinook salmon, hatchery steelhead trout, and wild steelhead trout from the head of Lower Granite Reservoir to Lower Granite Dam and to Little Goose Dam using PIT-tagged smolts marked at the traps and PIT-tagged smolts passing the traps from upriver hatchery releases and rearing areas.

5. Determine cumulative interrogation rate at Lower Granite, Little Goose, and McNary dams during the spring outmigration period for PIT-tagged spring/summer and age-0 chinook salmon, hatchery, and wild steelhead trout.

6. Correlate smolt migration rate with river flow for fish moving in riverine and reservoir environments.

7. Determine trap efficiency for each species at each trap over a range of discharges.

8. Test the new screw trap to determine effectiveness of the trap to collect age-0 chinook salmon smolts.

9. PIT-tag all age-0 chinook collected in the Snake River trap and screw trap and determine travel time and cumulative interrogation rate.

10. Evaluate timing of returning adult wild and natural steelhead crossing Lower Granite Dam.

METHODS

Releases of Hatchery-Produced Smolts

Anadromous hatchery release information was reported for hatchery smolts which contributed to the 1992 outmigration in the Snake River drainage, upstream of Lower Granite Dam. This information included species, number released, date, release location, number PIT-tagged, number freeze-branded, and associated brand.

Smolt Monitoring Traps

During the 1992 outmigration, three smolt monitoring traps were employed to monitor the passage of juvenile chinook salmon and steelhead trout. A scoop trap (Raymond and Collins 1974) was operated on the Clearwater River. Two other traps, a dipper trap (Mason 1966) and a screw trap (Murphy in press), were located on the Snake River (Figure 1). Smolts were captured and removed daily

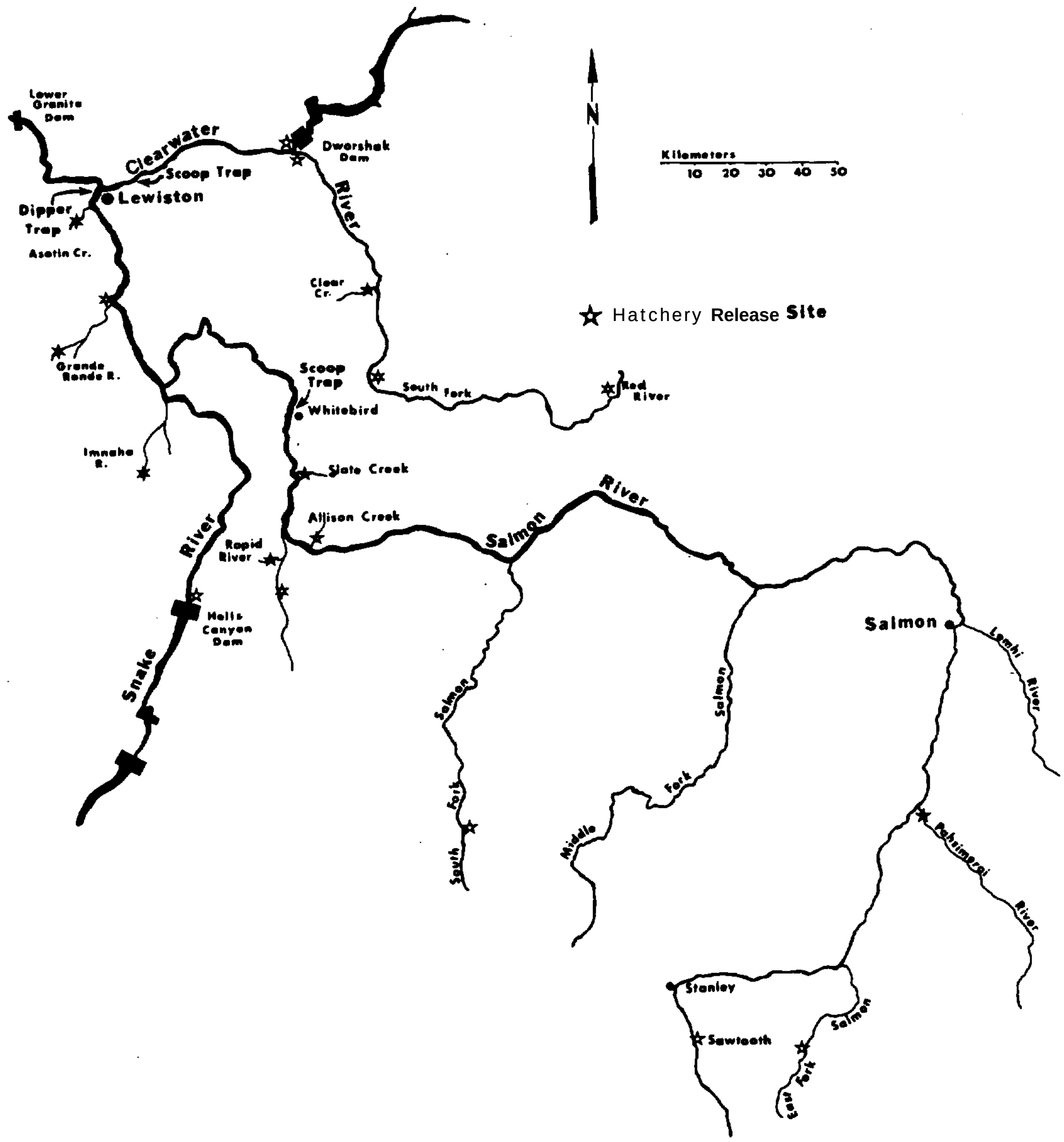

Figure 1. Map of study area.

from the traps for examination, enumeration, and released back to the river. Fork length of up to 100 smolts for each species was measured to the nearest millimeter and up to 2,000 fish were examined for hatchery brands. Smolts were anesthetized before handling withtricaine methanesulfonate (MS-222). These fish were allowed to recover from the anesthesia before being returned to the river.

At each trap, water temperature (C) and turbidity (m) were recorded daily using a centigrade thermometer and 20-cm secchi disk. The U.S. Weather Service provided daily information on river discharge (cfs). Snake River discharge was measured at the U.S. Geological Survey (USGS) Anatone gauge (#13334300), 44.4 km upstream from the dipper and screw traps. Clearwater River discharge was measured at the USGS Spalding gauge (#13342500), 8.8 km upstream from the Clearwater River trap.

Snake River Traps

The Snake River trap was positioned approximately 40 m downstream from the Interstate Bridge, between Lewiston, Idaho and Clarkston, Washington. The trap was attached to bridge piers just east of the drawbridge span by steel cables. This location is at the head of Lower Granite Reservoir, 0.5 km upstream from the convergence of the Sna1.e and Clearwater arms. River width and depth at this location are approximately 260 m and 12 m, respectively. The screw trap was attached to the Interstate bridge piers west of the drawbridge span.

Snake River trap operation in 1992 began March 10 and continued until July 24. During the month of March, the U.S. Army Corps of Engineers conducted an experimental drawdown of Lower Granite pool. As water levels dropped, a rock reef emerged directly upstream from the trap which reduced velocity through the trap to less than one foot per second (fps). A minimum velocity of approximately 1.6 fps is needed for efficient trap operation. The low water velocities experienced at the trap did not affect smolt collections significantly since few migrants were in the system at the time of drawdown.

Screw trap operation began on March 10 and continued until July 7. The screw trap was also affected by the March drawdown. As water levels decreased, water velocities increased. High velocities forced the anterior of the trap up and out of the water and submerged the posterior portion of the trap containing the live well. The top rear of the live well was open, allowing escape of any of the few migrants present that may have been captured.

Chinook salmon and steelhead trout smolts were PIT-tagged at the Snake River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam. Up to 150 chinook salmon, 60 hatchery steelhead trout, all wild steelhead trout, and all age-0 chinook salmon were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow discharge for the number of days equal to the median travel time to determine how changes in discharge affected smolt migration rate through Lower Granite Reservoir.

All fish captured in the Snake River trap were passively interrogated for PIT-tags as they entered the live well. All fish captured in the screw trap were interrogated when they were examined. The interrogation and tagging information was sent to the PTAGIS Data Center (managed by Pacific States Marine Fisheries Commission) daily.

The PIT-tag interrogation system on the Snake River trap consists of an 8-inch PVC pipe with two interrogation coils (D-4 and D-6). Each coil is connected to an exciter card and a PIT-tag reader. The system does not have the capability to provide exact time of capture. Since it is checked once daily, the interrogation time is set to 00:00 h. Coil efficiency tests were not conducted in 1992, but it was estimated to be 98.5% in 1991.

Clearwater River Trap

The Clearwater River scoop trap was installed 10 km upstream from the convergence of the Clearwater River and Snake River arms of Lower Granite Reservoir (4.5 km upstream from slack water). The river channel at this location forms a bend and is 150 to 200 m wide and 4 m to 7 m deep, depending on discharge.

Trap operation began March 13 and continued until June 11. The trap was out of operation for a total of nine days throughout the season. Trap operation was interrupted May 7 and May 10-17 due to mechanical failure.

Chinook salmon and steelhead trout smolts were PIT-tagged at the Clearwater River trap to estimate travel time from the head of Lower Granite Reservoir to Lower Granite Dam for Clearwater River fish. Up to 150 chinook salmon, 60 hatchery steelhead trout, and all wild steelhead trout were PIT-tagged daily, when available. Median travel time of the daily PIT-tagged release groups was converted to migration rate. This was correlated with mean Lower Granite Reservoir inflow discharge for the median travel time to determine how changes in discharge affected smolt migration rate through Lower Granite Reservoir.

All fish were interrogated for PIT-tags as the fish were removed from the live well. The tagging and interrogation files were sent to the PTAGIS Data Center daily.

The PIT-tag interrogation system on the Clearwater River trap consists of a 4-inch PVC pipe with two interrogation coils (D-O and D-2). Each coil is attached to an exciter card and a PIT-tag reader. This system is battery-operated. Coil efficiency tests were not conducted in 1992, but it was estimated to be 98.8% in 1991.

Trap Efficiency

The proportion of the migration run being sampled is termed trapping efficiency. Since trap efficiency may change as river discharge changes, efficiency has been estimated several times through the range of discharge at which the trap was operated. A linear regression equation (Ott 1977) describing the relation of trap efficiency and discharge was derived to estimate efficiency at any given discharge.

During the 1992 trap operations, trap efficiencies were calculated for the Clearwater River trap, but not for the Snake River trap. Trap efficiency was calculated using freeze-branded chinook salmon released from Dworshak National Fish Hatchery (DNFH) on April 15-16. Three brand groups, totaling 61,153, were released at the hatchery, and 1,957 were captured at the trap yielding a mean trap efficiency of 3.14% at 15 kcfs discharge. Trap efficiency begins to decline when discharge increases, mainly because of trap location. High discharge (above 25-30 kcfs) necessitates moving the trap out of the ideal trapping location. Previous trap efficiency estimates are reported in Buettner (1991).

Travel Time and Misration Rates

Migration statistics were calculated for hatchery release groups from release sites to traps. Travel time and migration rates to the traps were calculated using median arrival times at the Snake and Clearwater River traps. Median arrival (or passage) date is the date the 50th percentile fish arrived at the trap or collection facility. Smolts were PIT-tagged at the Snake and Clearwater River traps as the primary method to determine travel time from the head of Lower Granite Reservoir to Lower Granite and Little Goose dams. Distances from release point to recovery location are listed in Table 1. Individual arrival times at Lower Granite and Little Goose Dam collection facilities were determined for each daily release group. A minimum recapture number, sufficient for use in travel time and migration rate estimations, was derived from an empirical distribution function of the travel time for each individual release group (Steinhorst et al. 1988). If recapture numbers were less than five or less than the number derived from the empirical distribution function, the daily data were combined with another day's data or the data were not used. If they were combined, they were added to daily data from an adjacent release day that had similar discharge and travel time.

Smolt migration rate/discharge relations through Lower Granite Reservoir were investigated using linear regression analysis after both variables were log (ln) transformed (Zar 1984). The 0.05 level was used to determine significance. This analysis was performed for the PIT-tagged spring/summer chinook salmon, age-0 chinook salmon, hatchery steelhead trout, and wild steelhead trout groups marked at the Snake or Clearwater River traps.

To remove some of the "noise" often associated with biological data and better show the underlying biological relation, migration rate was stratified into 5-kcfs discharge intervals (Mosteller and Tukey 1977). A linear regression analysis was conducted on the stratified data.

A linear regression analysis was performed on the migration rate/discharge data for PIT-tagged fish released from the Snake and Clearwater River traps and interrogated at Little Goose Dam. Data that had been stratified into 5-kcfs discharge intervals and log (ln) transformed were used in the analysis.

The migration rate/discharge relations for PIT-tagged chinook salmon, hatchery steelheadtrout, and wild steelheadtrout were individually examined for 1988-1992 to determine if the relations differed between years. Using an analysis of covariance, with the migration rate data stratified by 5-kcfs groups, the first underlying assumption of equality of slopes was tested. If the hypothesis of equality of migration rate/discharge slopes among years was not rejected, then the subsequent analysis of covariance was completed. If the final hypothesis of common intercepts was not rejected, then there was not a significant difference in the migration rate/discharge relations among years and the yearly data were pooled. After pooling, a linear regression analysis was run to provide the best fitting equation to describe the relation between migration rate and discharge for an individual species over several years.

Interroqation Rate of PIT-Taqqed Fish

Interrogation rates of PIT-tagged fish, marked at the head of Lower Granite Reservoir, to Lower Granite Dam, Little Goose Dam, and McNary Dam collection facilities included data from 1988 to 1992 for the Snake River trap and 1989 to 1992 for the Clearwater River trap. The data have been examined to ensure that multiple interrogations within a dam and between dams have been removed.

Table 1. River mile and kilometer locations for the Snake River Drainage.

	Mouth of Columbia R.		Mouth of Snake River		Lower Granite Dam		Snake River trap site		Clearwater R. trap site		Salmon River trap site	
	mi	km	mi	km	mi	km	mi	km	mi	km	mi	km
Mouth of Snake River	324.3	521.8	0	0	107.5	172.9	139.6	224.6	145.7	234.5	241.4	388.4
Lower Granite Dam	431.8	694.8	107.5	173.0		0	32.1	51.6	38.3	61.5	133.9	215.4
Clearwater R. trap site	470.0	756.2	145.7	234.4	38.8	61.5	--	--	0	0	--	--
Highway 95 boat launch	473.2	761.4	148.9	239.6	41.5	66.8	--	--	3.2	5.1	--	--
Dworshak NFH	504.3	811.4	180.0	289.6	72.5	116.6	--	--	34.3	55.2	--	--
Kooskia NFH	541.6	871.4	217.3	349.6	109.8	176.7	--	--	71.5	115.0	--	--
Crooked River	604.3	972.3	280.0	450.5	172.5	277.6	--	--	134.3	216.0	--	--
Red River Rearing Pond	618.0	994.4	293.7	472.6	186.2	299.6	--	--	148.0	238.1	--	--
Snake River trap site	463.9	746.4	139.6	224.6	32.1	51.6	0	0	--	--	101.8	163.8
Asotin Creek rel. site	470.3	756.7	146.0	234.9	38.5	61.9	6.4	10.3	--	--	--	--
Mouth of Grande Ronde R.	493.0	793.2	168.7	271.4	61.2	98.5	29.1	46.8	--	--	--	--
Deer Creek	504.3	811.4	180.0	289.6	72.5	116.7	40.4	65.0	--	--	--	--
Cottonwood Creek	521.7	839.4	197.4	317.6	89.9	144.6	57.8	93.0	--	--	--	--
Wildcat Creek	546.2	878.8	221.9	357.0	114.4	184.3	82.3	132.4	--	--	--	--
Lookingglass Creek	580.4	933.9	256.1	412.1	148.6	239.1	116.5	187.4	--	--	--	--
gig Canyon Creek	585.9	942.7	261.6	420.9	154.1	247.9	122.0	196.3	--	--	--	--
Spring Creek	614.4	988.6	290.1	466.8	182.6	293.8	150.5	242.2	--	--	--	--
Catherine Creek	636.9	1024.8	312.6	503.0	205.1	330.0	173.0	278.4	--	--	--	--
Mouth of Salmon River	512.5	824.6	188.2	302.8	80.7	129.8	48.6	78.2	--	--	53.2	85.6
Imnaha River	516.0	830.3	191.7	309.1	84.2	135.7	52.1	83.8	--	--	--	--
Little Sheep Creek	553.8	891.1	229.5	369.3	122.0	196.3	89.9	144.6	--	--	--	--
Imnaha Colt. Facility	565.6	910.2	241.3	388.3	133.8	215.4	101.7	163.6	--	--	--	--
Hells Canyon Dam	571.3	919.2	247.0	397.4	139.5	224.5	107.4	172.8	--	--	--	--
Salmon River trap site	565.7	910.2	241.4	388.4	133.9	215.4	101.8	163.8	--	--	0	0
Rapid River Hatchery	605.8	974.7	281.5	452.9	174.0	280.0	141.9	228.3	--	--	40.1	64.5
Hazard Creek	618.7	995.5	294.4	473.7	186.9	300.7	154.8	249.1	--	--	53.0	85.3
S.F. Salmon @ Knox Bridge	719.7	1158.0	395.4	636.2	287.9	463.2	255.8	411.6	--	--	154.0	247.8
Pahsimeroi Hatchery	817.5	1315.4	493.2	793.6	385.7	620.6	353.6	568.9	--	--	251.8	405.1
E.F. Salmon @ trap site	873.6	1405.6	549.3	883.8	441.8	710.9	409.7	659.2	--	--	307.9	495.4
Sautooth Hatchery	896.7	1444.2	573.3	922.4	465.8	749.5	433.7	697.8	--	--	331.9	534.0

RESULTS AND DISCUSSION

Hatchery Releases

Chinook Salmon

Chinook salmon released into the Snake River drainage upstream from Lower Granite Dam were reared at ten locations in Idaho and one in Oregon. The Washington Department of Fisheries released no chinook salmon juveniles in the Snake River drainage upstream from Lower Granite Dam that contributed to the 1992 outmigration. A total of 10,926,802 chinook salmon smolts were released at 15 locations in Idaho and 2 locations in Oregon (Table 2).

During the late summer and fall of 1991, six groups of chinook salmon juveniles (1,389,268 chinook salmon) were released from Idaho hatcheries. All other chinook salmon releases for the 1992 outmigration were made during the spring of 1992 (Table 2).

Steelhead Trout

Steelhead trout were reared at five locations in Idaho, one in Washington, and two in Oregon for release into the Snake River drainage upstream from Lower Granite Dam. A total of 9,313,752 steelhead trout smolts were released at 14 locations in Idaho, 6 locations in Oregon, and 2 locations in Washington (Table 3). Fall releases of steelhead trout juveniles have not been included in this total.

Smolt Monitorins Traps

Snake River Trap Operation

The Snake River trap caught 1,887 age-l chinook salmon, 20 age-0 chinook salmon, 20,864 hatchery steelhead trout, 2,691 wild steelhead trout, and 40 sockeye/kokanee salmon O. nerka. Chinook salmon catch at the Snake River trap for 1992 was similar to other low flow years (1987, 1988, 1990 and 1991) and considerably lower than 1984-1986 or 1989, and near-normal to above-normal flow years. There appears to be a threshold velocity required within the trap to collect chinook salmon effectively. Below this threshold velocity, which is about 1.6 to 1.8 feet per second, trap efficiency is very low and chinook salmon trap catch will not be representative of the chinook salmon population passing the trap. The threshold velocity is generally exceeded when discharge is above 30 to 33 kcfs. The outmigration pattern (Figure 2) was similar to other years.

This was the second year that physical characteristics were used to differentiate between age-0 chinook salmon and other chinook salmon. The peak movement of age-0 chinook salmon was during May. Age-O chinook catch in the Snake River trap had virtually stopped by the end of June. The lack of age-0 chinook salmon in the Snake River trap catch was due to either a lack of fish movement or low water velocities reducing trap efficiency.

The screw trap collected 241 anadromous fish, of which 18 were age-0 chinook salmon. All of the age-0 chinook collected by the screw trap were too small (< 60 mm) to PIT-tag. The low trap catch was probably associated with the

Table 2. Hatchery chinook salmon released into the Snake River system upriver from Lower Granite Dam contributing to the 1992 outmigration.

Release site (hatchery)	Stock	Release date	No. released (No. branded) [No. PIT-tagged]	Brand
Salmon River				
South Fork Salmon River @ Knox Bridge (McCall)	Summer	3/23-27	901,500	
			(21,329)	RA-7U-1
			(20,520)	RA-7u-3
			(21,397)	LD-7U-1
			[500]	
Pahsimeroi Ponds (Pahsimeroi)	Summer	3/13-20	605,900	
			[298]	
Rapid River (Rapid River)	Spring	3/16-31	2,615,500	
			(19,858)	RA-R-1
			(19,536)	RA-R-2
			(21,842)	RA-R-3
			[268]	
East Fork Salmon River (Sawtooth)	Spring	3/30-31	76,614	
Sawtooth Weir (Sawtooth)	Spring	9/20/91	1,496	
			[1,496]	
		3/9-13	1,262,468	
			(19,987)	LA-T-l
			(20,121)	LA-T-2
			(20,444)	LA-T-3
			[7,196]	
Yankee Fork Dredge Ponds (Sawtooth)	Spring	6/18/91	50,480	
Yankee Fork (Sawtooth)	Spring	9/26-27/91	303,801	
	Drainage Total		5,817,759	
Snake River and Non-Idaho Tributaries				
Hells Canyon (Rapid River)	Spring	3/17-22	500,500	
			[279]	
Imnaha River @ River Km 74.8 (Lookingglass)	Spring	3/30	259,980	
			(20,134)	RD-A-2
			(20,565)	LD-A-2
			(20,630)	RD-A-4
			(20,889)	LD-A-4
			(20,675)	RA-J-2
			(20,462)	LA- J-2

Table 2. Continued.

Release site (hatchery)	Stock	Release date	No. released (No. branded) [No. PIT-tagged]	Brand
Lookingglass Cr. (Lookingglass)	Spring	3/31-4/1	950,868	
			(20,964)	RD-A-1
			(20,588)	LD-A- 1
			(20,458)	RD-A-3
			(20,419)	LD-A-3
	Drainage Total		1,711,348	
Clearwater River				
Clear Creek (Kooskia NFH)	Spring	4/7	205,214	
			(42,507)	RD-w-2
			(45,366)	RD-w-4
			[400]	
		4/15	138,418	
			[201]	
		4/21	190,483	
			(47,572)	LD-Y-2
			(39,939)	LD-Y-1
			[400]	
		5/5	193,136	
			(49,368)	LD-Y-4
			(46,910)	RD-w-1
			(4001	
Crooked River (Crooked River)	Spring	10/16/91	320,400	
			[492]	
Red River Pond (Red River)	Spring	10/23/91	354,700	
			[699]	
(Dworshak NFH)	Spring	4/08	207,519	
North Fork Clearwater @ Dworshak (Dworshak NFH)	Spring	4/15-16	959,369	
		4/15	(21,112)	LA-7C-3
		4/16	(21,229)	LA-7c-1
			(18,812)	RD-7c-3
			[1798]	
Eldorado Creek (Dworshak NFH)	Spring	3/18	183,000	
			[500]	
White Sands Creek Lochsa River (Powell Pond)	Spring	10/24/91	358,372	
			[700]	
(Dworshak NFH)		4/6	214,311	
			[1001]	

Table 2. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded) (No. PIT-tagged]	Brand
Papoose Creek (Kooskia NFH)	Spring	3/16	72,173	
	Drainage Total		3,397,695	
	GRAND TOTAL		10,926,802	

Table 3. Hatchery steelheadtrout released into the Snake River system upriver from Lower Granite Dam contributing to the 1992 outmigration.

Release site (hatchery)	stock	Release date	No. released (No. branded) [No. PIT-tagged]	Brand
<u>Salmon River</u>				
L. Salmon River @ Stinky Springs (Magic Valley)	A	4/14-21	436,100 [100]	
L. Salmon River @ Hazard Creek (Magic Valley)	A	4/17-25	565,800 [200]	
(Hagerman NFH)	B	4/14-22	300,534	
East Fork Salmon River (Magic Valley)	B	4/6-14	1,041,200 [299]	
East Fork Trap (Hagerman NFH)	B	4/6-9	302,335	
Salmon River @ Sawtooth (Hagerman NFH)	A	4/9-13	622,746 [1502]	
(Magic Valley)	A	3/23-24	117,300	
Pahsimeroi Ponds (Hagerman NFH)	A	3/25-27	223,406	
(Niagara Springs)	A	3/30-4/2	242,800 [297]	
Pahsimeroi Trap (Niagara Springs)	A	4/2-8	261,500 [300]	
Salmon River @ Hammer Creek (Niagara Springs)	A	4/13-17	282,300	
	Drainage Total		4,396,021	
<u>Snake River and Non-Idaho Tributaries</u>				
Hells Canyon (Babington)	A	4/22-27	417,064	
Hells Canyon (Niagara Springs)	A	4/18-21	243,900 [297]	
Spring Creek (Wallowa)	A	4/20 & 5/4	668,920	
		(4/20)	(20,665)	RD-A-1
		(4/20)	(20,310)	LD-A-1

Table 3. Continued

Release site (hatchery)	Stock	Release date	No. released (No. branded) [No. PIT-tagged]	Brand
Deer Creek @ Big Canyon Facility (Irrigon)	A	4/23 & 5/8	474,826	
		4/23	(20,484)	RD-A-2
			(20,792)	RD-A-4
			(19,991)	LD-A-4
		5/8	(20,973)	LD-A-2
Grande Ronde River R-2 @ River Km 273 (Irrigon)	A	4/6-8	200,214	
			(25,617)	RD-A-3
			(25,745)	LD-A-3
Little Sheep Creek (Irrigon)	A	4/27	248,642	
			(20,830)	RD-J-2
			(20,880)	LD-J-2
			(20,242)	RD-J-4
			(20,105)	LD-J-4
Imnaha River (Irrigon)	A	5/1	28,917	
Catherine Creek (Irrigon)	A	4/8	62,649	
Grande Ronde River @ River Km 47 (Lyons Ferry NFH)	A	4/6-17	213,622	
Grand Ronde River @ River Km 66 (Lyons Ferry NFH)	A	4/20-21	49,925	
	Drainage Total		2,608,679	
Clearwater River				
Clearwater River @ Dworshak Hatchery (Dworshak NFH)	B	4/30-5/1	1,224,101	
			(9,925)	RD-T-1
			(10,144)	RD-T-3
			(10,763)	LD-T-4
			[2,000]	
Clear Creek (Dworshak NFH)	B	4/16	349,210	
South Fork Clearwater River @ R.Km. 14.0 (Dworshak NFH)	B	4/20-23	265,003	
			(10,303)	LD-T-2
			[967]	
Mill Creek (Dworshak NFH)	B	4/20-23	158,455	
Cottonwood Creek (Dworshak NFH)	B	4/20-23	312,203	
	Drainage Total		2,309,052	
	GRAND TOTAL		9,313,752	

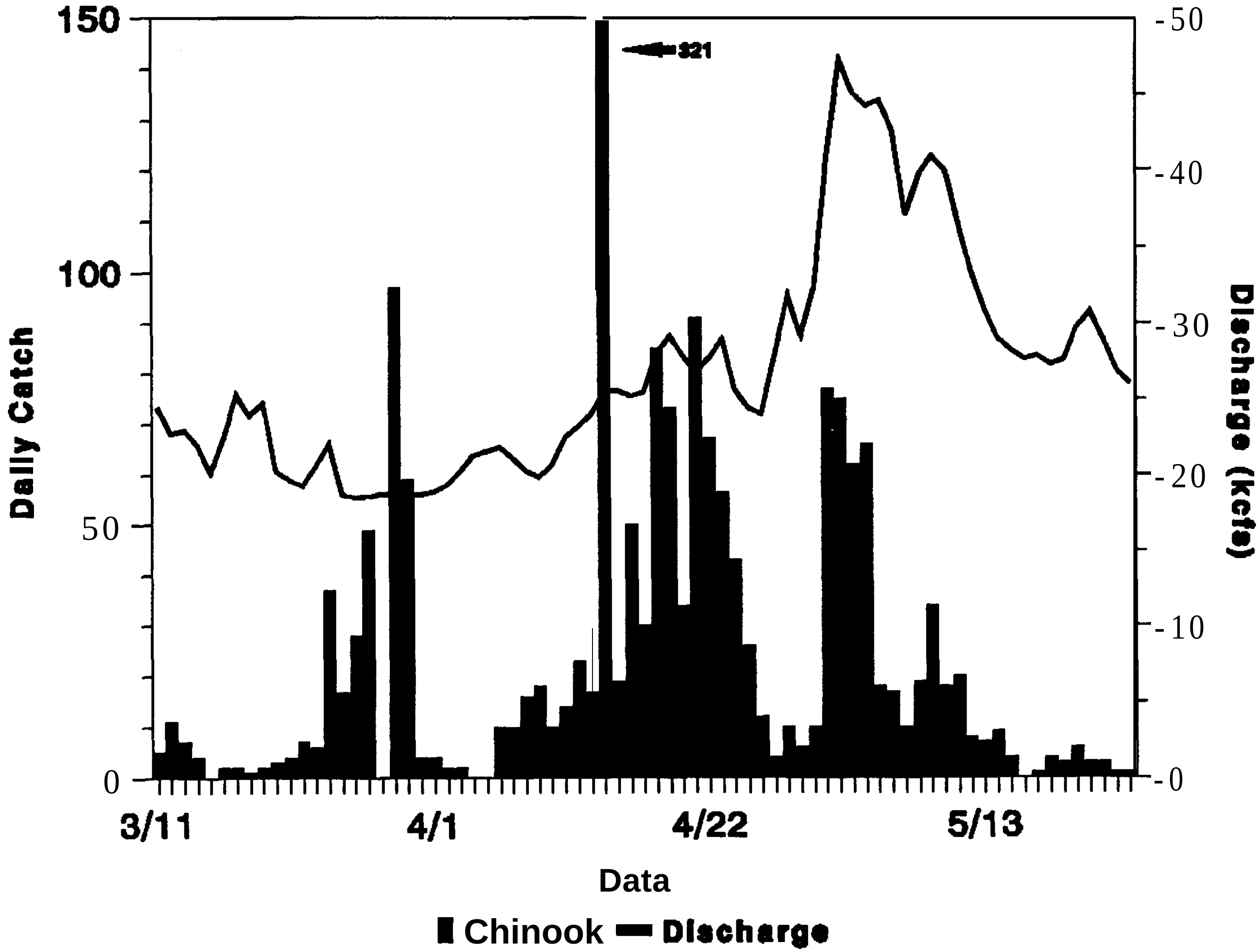

Figure 2. Snake River trap daily catch of age 1 chinook salmon overlaid by the Snake River discharge, 1992.

very low discharge encountered during the spring outmigration. The main purpose of the screw trap was to capture age-0 chinook salmon, but the 1992 season was not a good test of the screw trap's ability to catch fish.

There was one major and one minor peak in hatchery steelhead trout passage. The largest collection of hatchery steelhead trout began on April 15 and continued through May 15. During this period, 14,899 hatchery steelhead trout, or 71% of the season total, were collected. The minor peak of hatchery steelhead passage was May 19-23, when 5% of the season total was captured. Hatchery steelhead become stranded in Lower Granite Reservoir in extreme drought years, and more fish are caught at the trap in June than normal. Spring flows in 1992 were exceptionally low. Consequently, 17% of the hatchery steelhead season total was collected in June. During the previous three years, the percent collected in June ranged from 3% to 7%.

Twenty-four percent of the hatchery steelheadtroutwere captured in April, 57% in May, and 17% in June, 1992. The early portion of the run was shifted from late April to early May, probably due to a late runoff in the Salmon River drainage. Wild steelhead trout passage was earlier than hatchery steelhead trout, with 97% of the wild steelhead passage occurring by the end of May, and only 81% of the hatchery steelhead passage occurring by this time. Peak periods of passage were associated with increases in discharge. Thirty-two percent of the wild steelhead trout were captured in April, 65% in May, and 2% in June (Figure 3). Similar to the hatchery steelhead trout timing, the wild steelhead trout timing was delayed due to the late spring runoff in the Salmon River drainage.

Snake River trap catch for wild steelhead trout was about 50% less than the 1991 total of 4,136, but was similar to the years of 1988 and 1989. Wild steelhead passed the trap in large numbers April 15 through May 15. During this period, 2,398 wild steelhead (89% of the season total) were collected.

Snake River discharge, measured at the Anatone gauge, ranged from 18.4 kcfs to 25.7 kcfs and averaged 21.8 kcfs in March (Figure 3), which was 2.8 kcfs higher than in 1991 and 18.6 kcfs lower than in 1989. The average April discharge was 24.6 kcfs, with a peak of 32.3 kcfs on April 30. The April average was 4.5 kcfs higher than in 1991 and 33.9 kcfs lower than in 1989. Average daily flows remained below 25.0 kcfs until April 14. After April 14, discharge began to increase and peaked on May 2 at 47.2 kcfs for the month and for the year. The average May discharge was 32.7 kcfs, which was 12.7 kcfs lower than in 1991 and 19.3 kcfs lower than in 1989. Flows had dropped to 22.2 kcfs by the first of June and continued to decrease until June 12. For the remainder of the month, flows fluctuated between a low of 14.8 kcfs and a high of 19.2 kcfs. The average June flow was 16.9 kcfs, which was 31.6 kcfs lower than the 1991 average of 48.5 kcfs and 27.9 kcfs lower than 1989. Flows increased during the first few days of July and peaked on July 4 at 28.1 kcfe. Flows began to steadily decrease throughout the remainder of the month when flows reached 10.9 kcfs on July 31.

Water temperature in the Snake River at the traps steadily increased throughout the sampling season (Figure 4). By the end of the season, July 27, water temperature had risen to 24°C. Water temperatures were generally two to five degrees warmer in the 1992 field season than in 1991, with the exception of July when temperatures were approximately the same for both years.

Secchi disk transparency fluctuated throughout the sampling season (Figure 4), apparently influenced mainly by localized rain or thunderstorms. Secchi transparency showed no statistical correlation to discharge (r^2=0.130, N=101, P<0.001). The lowest secchi disk transparency of 0.1 m on May 19 was associated with the maximum discharge for the season.

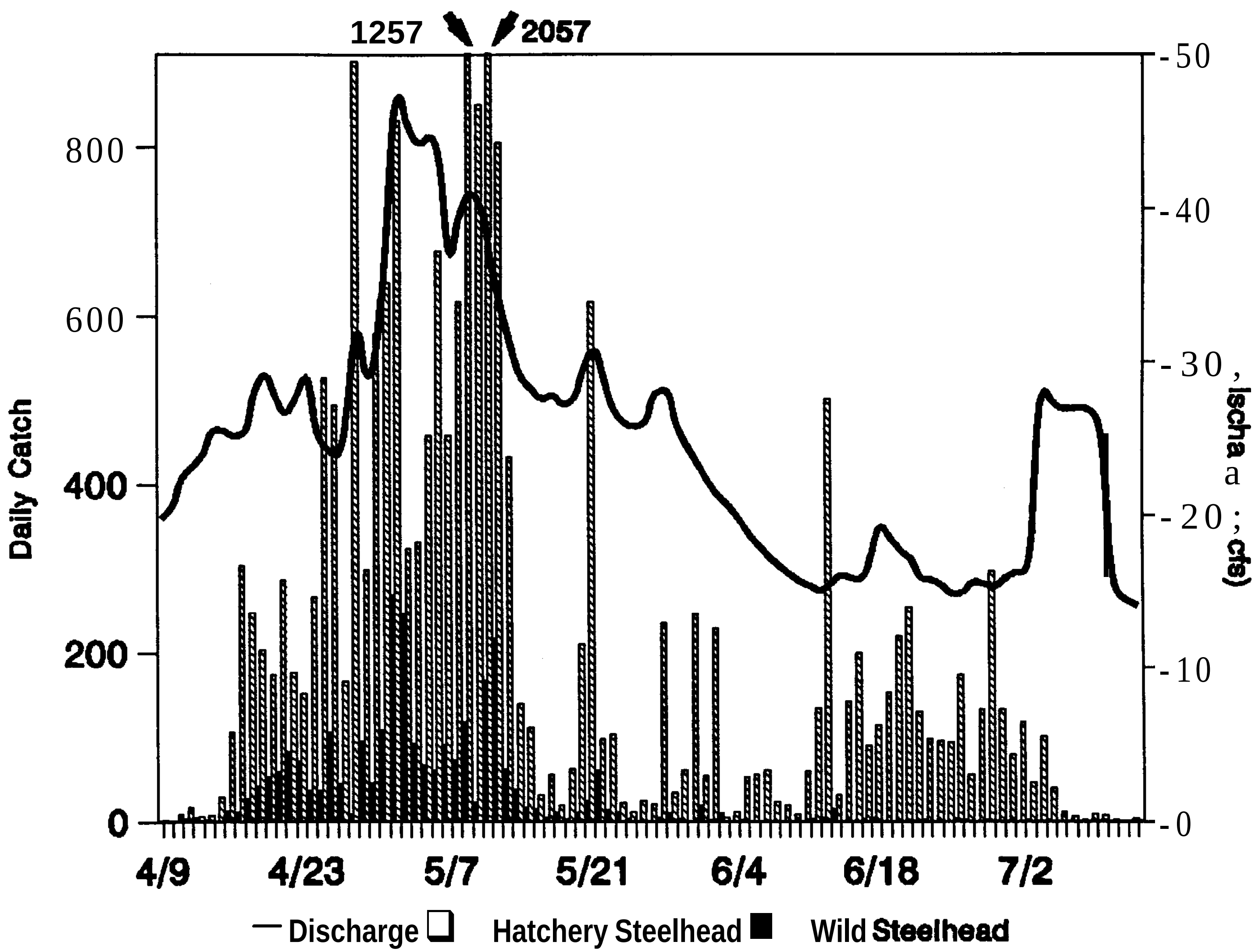

Figure **3.** **Snake River trap daily catch of hatchery eteelhead trout and wild eteelhead trout overlaid by Snake River discharge, 1992.**

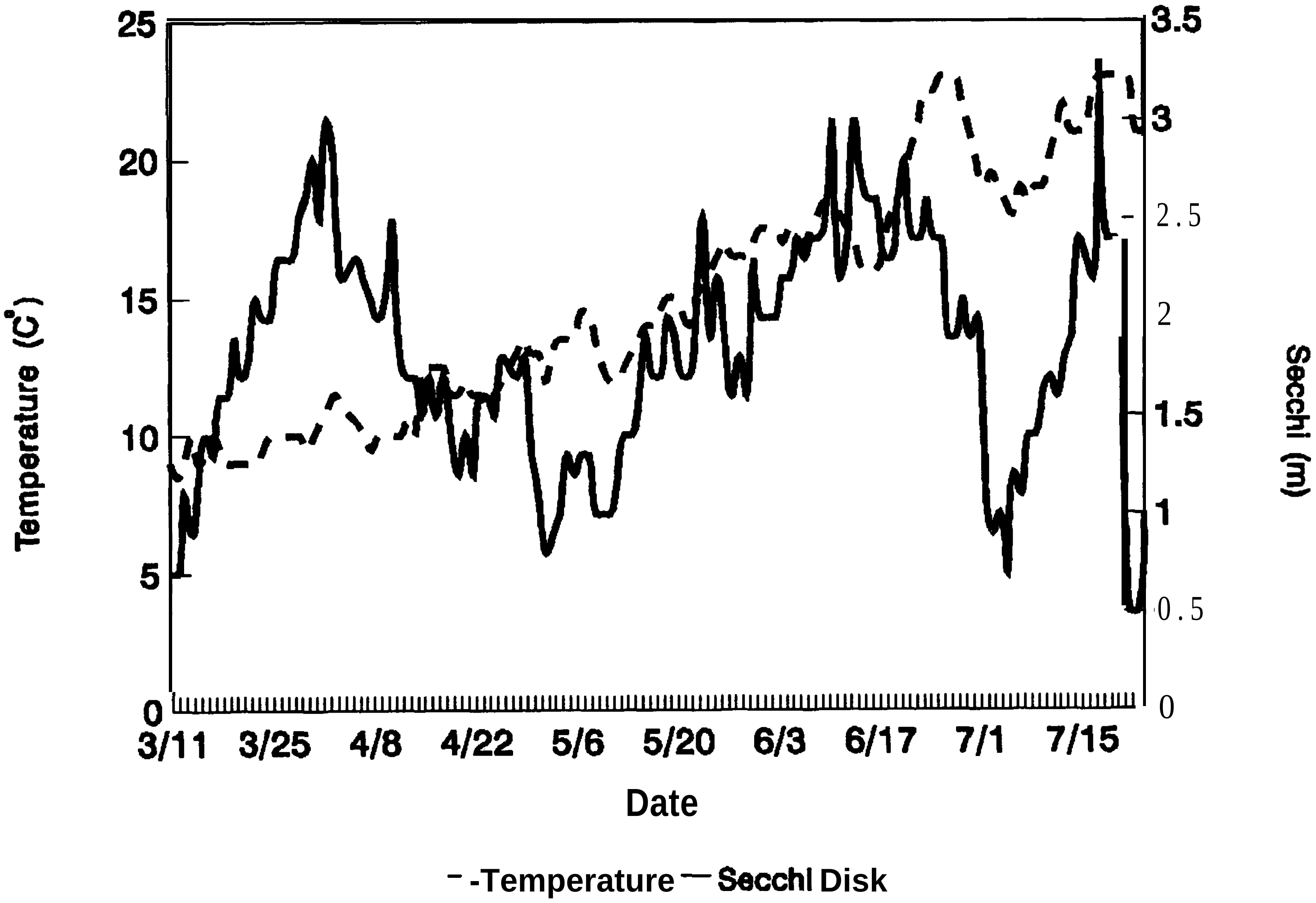

Figure 4. Daily temperature and **secchi disk transparency** at the Snake River trap, 1992.

Clearwater River Trap Operation

The Clearwater River trap caught 85,434 age-l chinook salmon, 21 age-0 chinook, 7,143 hatchery steelhead trout, 3,507 wild steelhead trout, and 42 sockeye/kokanee salmon in 1992. Chinook salmon catch for 1992 was about 2.2 times greater than the 1991 total of 39,522 and approximately 8.5 times greater than the lowest trap catch of 9,938 in 1989. The 1992 chinook salmon trap catch was the highest since trap operation began in 1984. The 1992 hatchery steelhead trout trap catch was 23% lower than the 1991 catch, 76% lower than 1990, but six times higher than 1989, a near-normal flow year. Wild steelhead trout trap catch was the highest since trap operation began (1984) and 2.3 times greater than the second highest year (1990).

Two major peaks of chinook salmon passage were observed at the Clearwater River trap (Figure 5). The first began on April 3 and ended on April 15. This peak was associated with chinook salmon passing the trap from Kooskia National Fish Hatchery (NFH) releases. The second peak was on April 16 through 24 and was probably associated with the releases from Kooskia NFH, Dworshak NFH, and fall-released smolts from Powell, Crooked River, and Red River rearing ponds.

Hatchery steelhead trout began showing up in the trap catch in high numbers (>100 fish per day) on April 21. There was a major movement of hatchery steelhead trout outplanted in the Clearwater River upstream from Dworshak NFH prior to the Dworshak NFH release. The major peak occurred on May 1 and was associated with the Dworshak NFH release (Figure 6). Overall hatchery steelhead trout catch was lower in 1992 than in 1991 because high discharge forced the trap out of the optimal thalweg position during the passage of the Dworshak Hatchery release.

Wild steelhead trout were present in the trap catch in low numbers (one to eight fish per day) from March 15 until April 1. The first of three peaks began on April 1 and lasted until April 22 (Figure 6). The second began on April 28 and continued through May 1. The third and final peak began on May 18 and continued through June 4. Trap catch of wild steelhead trout in 1992 was about four times higher than in 1991. This is probably a function of trap location rather than a higher number of wild steelhead trout migrating out of the system. In 1992, the trap was operated for a longer period of time near the thalweg than it was in 1991. The trap was in the ideal position during the bulk of the 1992 wild steelhead outmigration. However, in 1991 the trap was moved out of ideal position due to high discharge at the peak of the outmigration.

Water temperature at the Clearwater River trap at the beginning of the season was 7°C, and gradually increased to 16°C by the end of the trapping season on June 12 (Figure 7). Water temperatures fluctuated throughout the season due to localized precipitation and releases of cooler water from Dworshak Reservoir.

Secchidisktransparency in the Clearwater River fluctuated throughout the trapping season and ranged from 0.1 m to 2.4 m (Figure 7). There was a significant statistical correlation between secchi disk transparency and discharge (r^2=0.171, N=61, P=0.001), but the relation was weak.

Trap Efficiency

Snake River Trap

Chinook Salmon-Trap efficiency for chinook salmon smolts at the Snake River trap was not tested in 1992. Sufficient numbers of fish were not available for

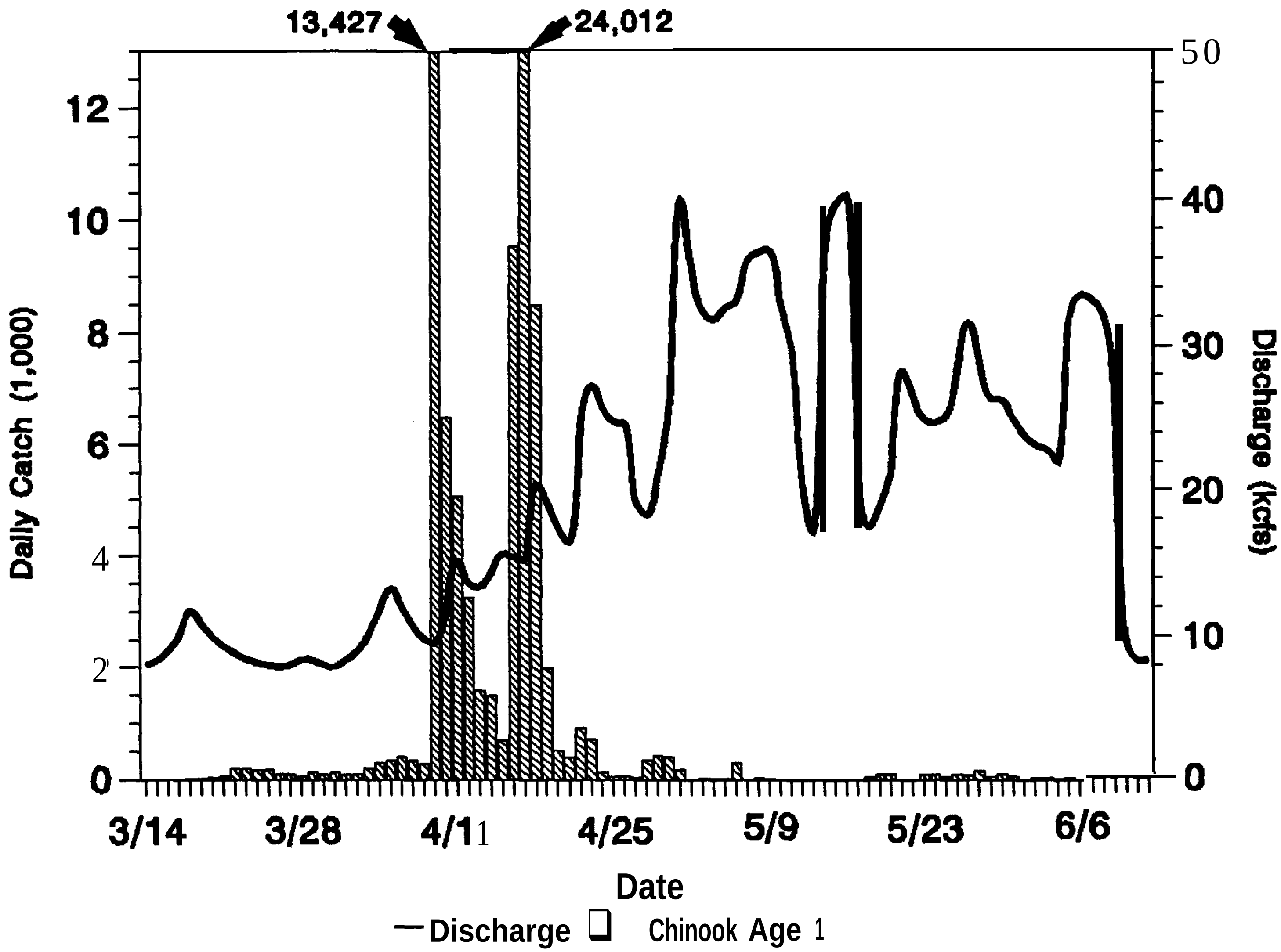

Figure 5. Clearwater River trap daily catch of age 1 chinook salmon overlaid by Clearwater River Discharge, 1992.

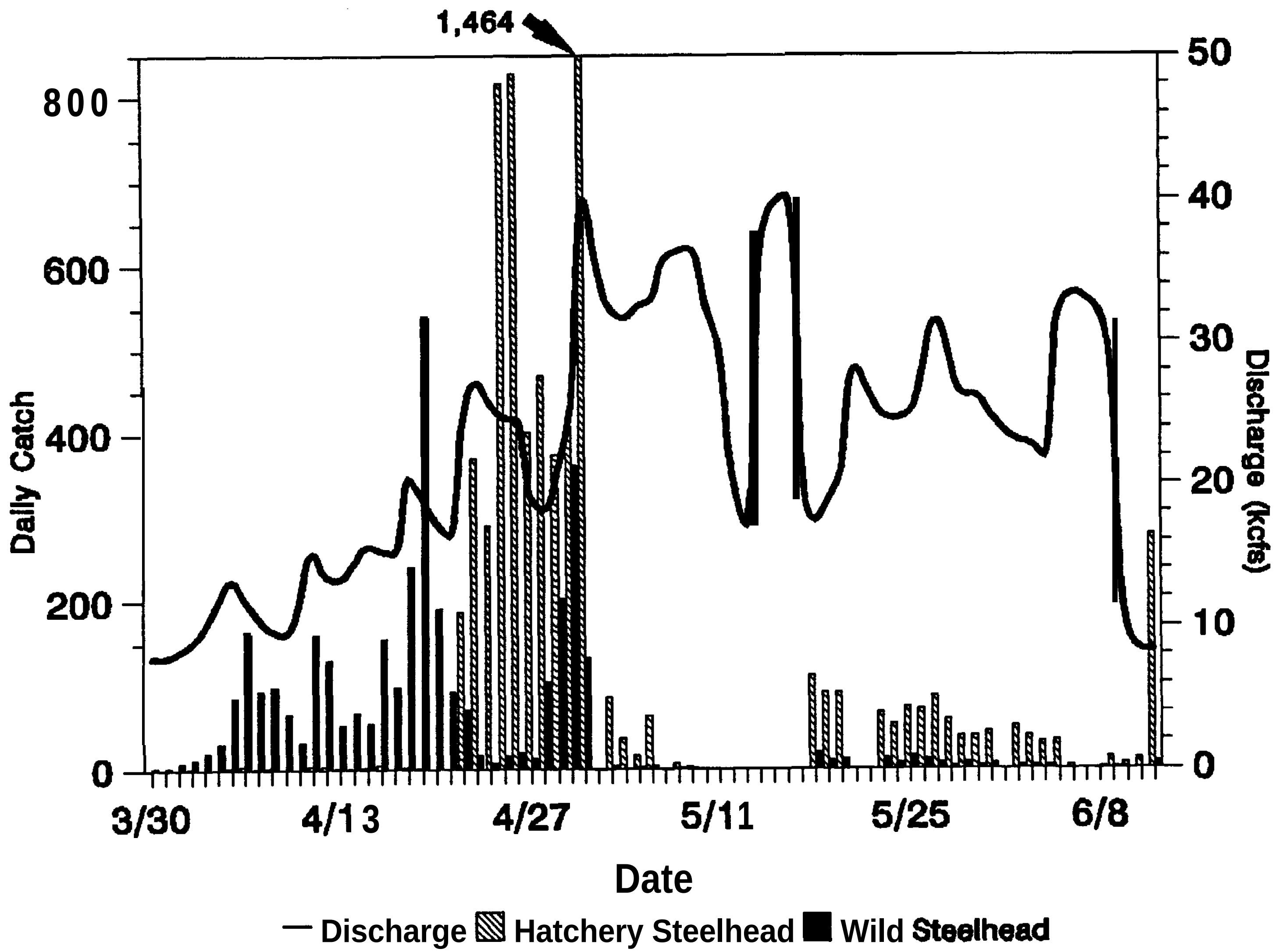

Figure 6. Clearwater River trap daily catch of hatchery steelhead trout and wild steelhead trout overlaid by Clearwater River discharge, 1992.

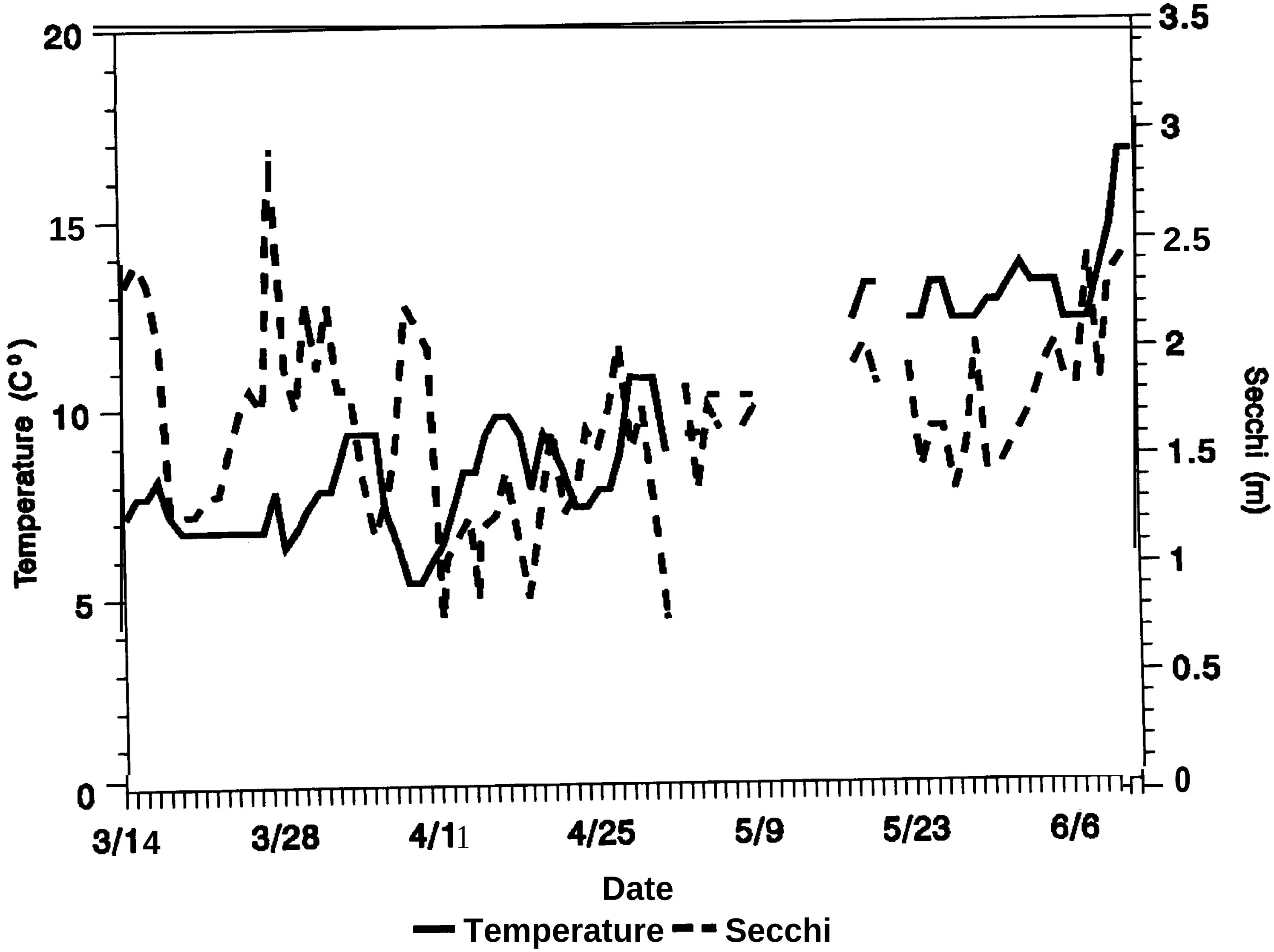

Figure 7. Daily temperature and secchi disk transparency at the Clearwater River trap, 1992.

trap efficiency estimates. The mean trap efficiency for chinook salmon at the Snake River trap, with four yearly estimates during the past seven years, is 1.39%. All four of these estimates were made when the trap was fishing on the west side of the river. Trap efficiency estimates for chinook salmon have not been conducted with the trap fishing on the east side of the river. Also, trap efficiency is much lower (probably < 0.1%) than this estimate when discharge is below 30 to 33 kcfs. During 1992, discharge was below 33 kcfs for most of the chinook outmigration season.

Steelhead Trout-No trap efficiencytestswere conducted for steelheadtrout smolts in 1992. The 1990 data yielded a mean trap efficiency of 0.49% and 95% confidence limits of 0.13% and 1.08%.

The analysis of variance, to test if trap efficiency varies among years when adjusted for discharge, was not valid due to the limited data available in 1985 and 1986. Data from 1988-1990 were analyzed. No significant difference was observed for the three years of data. A regression analysis was conducted on the pooled data to determine if there was a relation between discharge and trap efficiency. The analysis failed to show a significant relation (r^2=0.001, N=10, P=0.937).

All five years of data (1985, 1986, and 1988-1990) were pooled to provide a grand mean trap efficiency. The five-year grand mean of the Snake River trap efficiency for hatchery steelhead trout was 0.68% with a 95% confidence interval of 0.43% and 0.97%.

Clearwater River Trap

Chinook Salmon-In 1992, three groups of two replicates each of freeze-branded chinook salmon were released from Kooskia NFH on April 4 and 21 and May 5. One group of three replicates was released from Dworshak NFH on April 14 and 15. The mean Clearwater River trap efficiency for the Kooskia group released on April 7 was 1.9% at a mean discharge of 11 kcfs. Mean trap efficiency for the group released on April 21 was 0.6% at a mean discharge of 22 kcfs. Mean trap efficiency for the final group released on May 5 was 0.26% at a mean discharge of 33 kcfs. The Clearwater River trap efficiency estimate using the three replicates released from Dworshak was 3.14% (at 15 kcfs) which was up from the 1991 estimate of 1.5%. The 1990 mean trap efficiency was 1.41% with 95% confidence limits of 1.03% and 1.86%. Between 1984 and 1989, an additional 42 trap efficiency tests were conducted on the Clearwater River trap for chinook salmon smolts (Table 4). Data from 1991 and 1992 were not added to the previous years* information for statistical analysis due to the low numbers of brand groups. The analysis of covariance on the 1984-1990 log transformed data revealed a significant difference in trap efficiency among years (F=3.666, N=51, P=0.005). Upon examination of the yearly efficiency data, 1989 appeared to be significantly different. The 1989 data were removed and the analysis of covariance rerun. Without the 1989 data, the slopes of the other years data were not significantly different (F=1.295, N=42, P=0.292). Continuing with the analysis, the intercepts (height) of the lines were not found to be significantly different (F=1.514, N=42, P=0.211). The data were pooled and a linear regression analysis was conducted. The analysis indicated there was a significant statistical correlation between trap efficiency and discharge, but only 18% of the variation in efficiency can be attributed to changes in discharge (r^2=0.183, N=42, P=0.005). The mean chinook salmon trap efficiency for the pooled data, excluding 1989, 1991, and 1992 was 2.02% with 95% confidence limits of ±0.43%. The mean trap efficiency for 1989 was 1.04%, which was considerably lower than that of the pooled years but similar to the 1991 estimate (1.16%).

Table 4. Clearwater River trap efficiency tests for chinook salmon smolts, 1984-1992.

Year	Sample origin	Release dates	Recaptures/ marked	Efficiency	Discharge (kcfs)
1992	Dworshak	4/15	1,134/21,112	0.0537	15
	Nat'l Fish	4/16	548121,229	0.0258	15
	Hatchery (DNFH)	4/16	275/18,812	0.0146	15
	Kooskia	4/07	925/42,507	0.0218	11
		4/07	731145,366	0.0161	11
		4/21	186147,572	0.0039	22
		4/21	346/39,939	0.0087	22
		5/05	104/46,910	0.0022	33
		5/05	144149,368	0.0029	33
1991	DNFH	4/3	360/19,704	0.0183	12
		4/3	204/16,884	0.0121	12
1990	Hwy 95	3/21	27/2,609	0.0103	22
	boat	3/26	28/2,266	0.0124	13
	launch	3/28	37/2,195	0.0169	13
		3/30	5612,061	0.0272	12
		4/2	3312,136	0.0154	17
	DNFH	4/5	23/1,418	0.0162	21
		4/5	180/20,239	0.0089	21
		4/5	163/19,900	0.0082	21
		4/5	282/19,730	0.0143	21
1989	Hwy 95	3/21	7/2,076	0.0034	17
	boat	3/23	10/2,065	0.0048	15
	launch	4/3	3912,094	0.0186	20
		4/5	41/2,075	0.0200	21
	DNFH	3/29	66134,795	0.0019	24
	release	3/29	73130,503	0.0024	24
		3/30	41/19,087	0.0021	23
		3/30	48/19,545	0.0025	23
		3/30	78/20,084	0.0039	23
1988	Hwy 95	3/14	51/2,197	0.0232	6
	boat	3/17	93/2,197	0.0423	6
	launch	3/21	8312,197	0.0378	6
		4/1	2712,195	0.0123	9
		4/6	18/2,194	0.0082	11
		4/13	31/2,193	0.0141	14
1988	DNFH	3/30	1,711/60,631	0.0282	10
	release	3/30	25218,731	0.0289	10
		3/30	181/6,163	0.0294	10
		3/30	788/20,642	0.0382	10
		3/30	573122,935	0.0250	10
	trap	3/24	17/2086	0.0081	9
	caught	3/28	27/1695	0.0159	12
		4/1	16/1631	0.0098	9
		4/2	38/2257	0.0168	8

Table 4. Continued.

Year	Sample origin	Release dates	Recaptures/ marked	Efficiency	Discharge (kcfe)
1987	DNFH release	3/20	43/2,160	0.0199	13
		4/22	50/2,000	0.0250	6
		4/7	165/1,945	0.0848	10
		4/13	74/2,000	0.0370	13
		4/20&28	103/4,000	0.0258	18
	trap caught	4/2	33/1,926	0.0171	6
		4/3	11/1,458	0.0075	8
		4/6	15/1,872	0.0080	9
		4/7	15/1,163	0.0129	10
		4/9	9/450	0.0200	12
1986	trap caught	3/27	9/1,555	0.0058	22
		4/2	8/1,714	0.0047	29
1985	trap caught	3/25	14/607	0.0230	9
		3/30	45/1,511	0.0298	9
		4/5	6/1,079	0.0056	18
		4/9	2/940	0.0021	15
		4/16	7/929	0.0075	33
1984	trap caught	4/5	4/418	0.0096	21
		4/21	13/806	0.0161	33
		4/25	3/489	0.0061	31
		5/10	14/453	0.0309	24

Steelhead Trout-No trap efficiency tests were conducted in 1992. The most recent mean trap efficiency (1990) was 1.90% with 95% confidence limits of 1.42% and 2.46%. This is the highest trap efficiency observed for the Clearwater trap. One possible explanation for this very high efficiency is the trap was in an ideal fishing location, with respect to water conditions, during the test period. This type of positioning is difficult to maintain throughout a sampling season because the trap fishes such fast water that slight increases in discharge or debris load could be detrimental to the trap.

During the past seven years, Clearwater River trap efficiency for steelhead trout has been tested 20 times. Only 14 of these tests yielded valid results. The other six had recovery numbers less than five and could not be used in the analysis. An analysis of covariance shows a significant difference in trap efficiency among years ($F=30.439$, $N=14$, $P<0.001$). Therefore, data from all years were not pooled to derive any statistical inference. Hatchery steelhead trap efficiency ranged from 0.12% to 3.03% during the six years efficiency was tested and is generally below 0.5%.

Travel Time and Migration Rates

Release Sites to Snake River Trap

Chinook Salmon-There were nine groups of freeze-branded chinook salmon released in the Salmon River drainage: three each at Sawtooth Hatchery, South Fork Salmon River, and Rapid River Hatchery. Six groups were released in the Imnaha River, Oregon, and four groups were released in Lookingglass Creek, Oregon.

Because of extremely low brand recovery at the Snake River trap sites (53 branded chinook salmon were captured out of approximately 390,818 branded fish released in 1992), migration rate statistics were not calculated for chinook salmon in 1992 (Table 5). Low brand recoveries were probably due to drought conditions throughout the Salmon River and Snake River drainages creating low flow conditions which adversely effect trap efficiency.

Steelhead Trout-In 1992, there were no freeze-branded steelhead trout groups released above the Snake River trap from Idaho hatcheries. Oregon hatcheries released 12 groups of freeze-branded steelhead trout upstream of the Snake River and screw traps: two groups of two replicates each from Little Sheep Creek, two groups of two replicates each from Deer Creek, one group of two replicates from Spring Creek, and one group of two replicates from the Grande Ronde River. Recapture numbers were high enough for the four groups released at Deer Creek and the two groups released at Spring Creek to provide travel time information to the Snake River trap (Table 6).

Two of the four brand groups released at Deer Creek were acclimated before release. The remaining two groups were released directly into the stream. The migration rate for the acclimated and non-acclimated groups were 32.7 km/d and 39.3 km/d, respectively. The migration rate for the Deer Creek release was approximately two times faster than it was in 1991. Mean flows during the migration period, measured at the Anatone, Washington gauge and date of release were virtually the same for both years (Table 6). The migration rate for the two Spring Creek groups were 15.1 km/d and 12.1 km/d. The migration rates were about the same as observed in 1991; however, 1992 mean flows were about 10.0 kcfs higher than in 1991. Differences in migration rates for Grande Ronde River steelhead may be partially explained by yearly variations in flows, water temperature, and level of smoltification.

Table 5. Migration data for freeze-branded chinook salmon smolts from release **sites to the Snake River trap,** 1987-1992.

Release site	year	Median release date	Median passage date	Number captured	Travel **time (days)**	Migration rate **(km/day)**	Mean **discharge (kcfs)** Salmon R.	Snake R.
Rapid River	1992	a--	--	--	--	--	--	--
	1991	a--	--				--	--
	1990	a--	--	--	--	--	--	--
	1989	**3/30**	**4/18**	181	19	12.0	9.0	52.6
	1988	a--	--		--	--		
	1987	a--	--	--	--	--	--	
Hells Canyon	1988	a--	--	--	--	--	--	--
	1987	a--	--	--	--	--		
S.F. Salmon River	1992	a--	--	--	--	--		--
	1991	**3/20**	**5/19**	80	60	6.9	8.2	24.6
	1990	a--	--	--	--	--	--	--
	1989	3/21	**5/11**	21	51	8.1	6.5	57.1
	1988	a--	--	--	--	--	--	--
	1987	a--	--	--	--	--		--
Sawtooth Hatchery	1992	L,	--	--	--	--	--	--
	1991	a--	--	--				--
	1990	a--	--	--	--	--	--	--
	1989	**3/15**	**4/20**	14	36	19.4	6.1	51.0
	1988	a--	--	--	--	--	--	--
	1987	L-	--		--	--		
Lookingglass Cr.	1992	a--	--	--	--	--	--	
	1991	**4/01**	**4/08**	26	7	26.7	--	19.0
	1990	a--	--	--	--	--	--	--
	1989	**4/03**	**4/06**	212	3	62.5		46.1
	1989	**4/03**	**4/05**	173	2	93.7	--	45.9
	1989	**5/15**	**5/18**	131	3	62.5	--	50.2
	1988	**5/13**	**5/16**	52	3	62.5	--	40.6
	1987	a--	--	--	--	--		
Imnaha River	1992	a--	--	--	--	--		
	1991	**3/22**	**4/12**	31	21	4.0	--	18.0
	1990	a--	--	--	--	--	--	--
	1989	**4/05**	**4/10**	247	5	16.8	--	51.6

a Insufficient recapture numbers at the Snake River trap.

Table 6. Migration data for freeze-branded steelhead trout smolts from release sites to the Snake River trap, 1987-1992.

Release site	year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Snake River mean discharge (kcfs)
Deer Creek at	1992	4/23	4/29	40	6	32.7	26.8
Big Canyon		4/23	4/28	45	5	39.3	26.3
Facility	1991	4/26	5/10	29	14	14.0	27.1
		4/26	5/09	45	13	15.1	25.8
		4/26	5/09	50	13	15.1	25.8
		4/26	5/03	43	7	28.0	23.6
Spring Creek	1992	4/20	5/06	27	16	15.1	33.4
		4/20	5/10	20	20	12.1	34.6
	1991	4/22	4/30	19	8	30.3	22.7
		4/22	5/10	22	18	13.5	25.9
		4/22	5/09	16	17	14.2	24.8
		4/22	5/11	16	19	12.7	26.9
	1990	4/17	4/30	115	13	18.6	35.6
		4/19	4/26	116	7	34.6	36.1
		4/17	4/28	125	11	22.0	35.0
	1989	4/24	5/01	84	7	34.6	62.0
		4/22	5/05	70	13	18.6	62.4
		4/22	5/02	83	10	24.2	63.8
	1988	4/17	4/25	28	8	30.3	34.5
		4/17	4/23	28	6	40.4	35.7
		4/17	4/25	30	8	30.3	34.5
		4/17	4/23	14	6	40.4	35.7
		4/18	4/25	38	7	34.6	35.0
		4/18	4/24	21	6	40.4	35.7
	1987	4/26	[a]--	--	--	--	--
cottonwood Creek	1987	4/26	4/30	28	4	23.3	39.3
Little sheep Cr.	1992	4/27	[a]--			--	--
	1991	4/23	5/12	27	19	7.6	28.1
		4/23	5/12	46	19	7.6	28.1
		4/23	5/10	32	17	8.5	26.3
		4/23	5/09	24	16	9.0	25.2

Table 6. continued.

Release site[a]	Year	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Snake River mean discharge (kcfs)
Little Sheep Cr.	1990	4/17	4/26	33	9	16.1	35.2
	1989	4/23	4/25	93	2	72.3	70.7
	1987	5/02	[a]--	--	--	--	--
Wildcat Creek	1990	4/25	4/28	84	3	44.2	34.7
	1989	4/26	4/30	134	4	33.2	60.7
	1988	4/23	4/26	152	3	44.2	32.7
Asotin Creek	1990	4/17	4/18	88	1	9.2	31.7

[a] Insufficient recaptures at the Snake River trap to derive fish movement data.

Release Sites to the Clearwater Trap

Chinook Salmon-In 1992, there was one group of three replicates of freeze-branded chinook salmon released from Dworshak NFH on April 15 and 16 (Table 7). Migration rate for age-l chinook salmon was 55.2 km/d. This was identical to the migration rate in 1988, 1989, 1990, 1991. The migration rate for Dworshak NFH chinook was much slower in 1987 (18.4 km/d). Average discharge during the migration period in 1987 was 7.2 kcfs, and ranged from 25% to 76% less than other study years. The extreme low discharge in 1987 is most likely responsible for the 75% reduction in travel time that year.

Three groups of two replicates each *were* released at Clear Creek (Kooskia NFH) on April 7, April 21, and May 5. Migration rate for age-l chinook released on April 21 and May 5 was 115.0 km/d, while the migration rate for the April 7 group was 57.5 km/d. *For* both the April 21 and May 5 releases, average discharges for the Middle Fork Clearwater River were 20.4 kcfs and 32.7 kcfs, respectively. At the time of the April 7 release, discharge was 9.9 kcfs. The low discharge encountered by the April 7 release group probably explains the slower migration rate.

Steelhead Trout-There were three groups of freeze-branded steelhead trout released from Dworshak NFH in 1992 totalina 30,832 fish. The median release date was April 30, and median passage date at the Ciearwater trap was May 1 (Table 7). Percent brand recovery at the trap was extremely low, only 0.11%, because of poor trap location associated with high discharge during this period (32.7 kcfs). Migration rate for this release group was 55.2 km/d and was the same as observed in 1988, 1989 and 1990.

Head of Lower Granite Reservoir to Lower Granite Dam

Chinook Salmon PIT-Taq Groups-In 1992, sufficient numbers of chinook salmon were PIT-taqqed dailv at the Snake River trap to provide 12 daily release groups (1,025 total PIT-tagged chinook salmon) for estimating travel time and migration rates through Lower Granite Reservoir. The number of PIT-tagged chinook salmon at the Snake River trap was the lowest of the past six years (1987-1992). The low number of chinook tagged in 1992 can be explained by lower than normal flows throughout the migration season. Median travel time ranged from 11.8 d early in the migration season to 6.6 d in early *May* (Table 8). Chinook salmon PIT-tag information for 1992 may not be representative of season averages due to the lack of data *over* the entire season.

Upon examination of the linear regression analysis of migration rate and discharge a correlation was found. The linear regression of the log of migration rate and log discharge provided the best fit for PIT-tagged chinook salmon groups released from the Snake River trap (r^2=0.615, N=12, P=0.003):

$$\ln(\text{migration rate}) = -0.941 + 0.682 \ln(\text{average discharge}).$$

This analysis indicates that PIT-tagged chinook salmon migration rate increased in Lower Granite Reservoir as discharge increased.

The linear regression analysis on the data stratified by 5-kcfs intervals provided the following best linear regression equation (r^2=0.693, N=6, P<0.040):

Table 7. Migration data for freeze-branded chinook salmon and steelhead trout smolts released upstream of the Clearwater River trap, 1987-1992.

Release site	year	Species	Median release date	Median passage date	Number captured	Travel time (days)	Migration rate (km/day)	Mean discharge (kcfs)
Dworshak NFH	1992	SH	4/30	5/1	36	1	55.2	32.7
		CH	4/16	4/17	1,957	1	55.2	15.2
	1991	SH	4/30	5/2	98	2	27.6	37.4
		CH	4/3	4/4	465	1	55.2	11.9
	1990	SH	5/3	5/4	1,060	1	55.2	22.3
		CH	4/5	4/6	625	1	55.2	21.1
	1989	SH	5/1	5/2	123	1	55.2	31.2
		CH	3/29	3/30	139	1	55.2	23.5
		CH	3/30	3/31	167	1	55.2	23.3
		CH-0	3/30	4/3	48	4	13.8	22.2
		CH	9/28/88	3/30	2	183	--	--
	1988	SH	5/3	5/4	283	1	55.2	16.9
		SH	5/4	5/5	202	1	55.2	16.9
		CH-0	3/30	4/1	239	2	27.6	9.8
		CH	3/30	3/31	1,711	1	55.2	9.6
		CH	3/30	3/31	1,359	1	55.2	9.6
		CH	3/30	3/31	434	1	55.2	9.6
		CH	9/28/87	3/27	16	182	--	--
	1987	SH	4/21	4/22	58	--[a]	--	--
		CH	4/1	4/4	1,416	3	18.4	7.2
Kooskia NFH	1992	CH	4/7	4/9	1,656	2	57.5	9.9
		CH	4/21	4/22	532	11	15.0	20.4
		CH	5/5	5/6	248	11	15.0	32.7
Red River Pond	1989	CH	10/17/88	4/17	19	182	--	--
	1988	CH	9/30/87	4/14	18	198	--	--
Crooked River	1987	SH	4/14	--	2		--	--
Clear Creek	1987	SH	4/17	4/20	59	3	38.3	14.1

[a] The release was made over 4 days and migration rate cannot be calculated over such a short distance.

Table 8. PIT-tagged chinook **salmon** travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval [a] Upper	Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
4/7[b]	11.80	9.40	12.70	50	33.3	37.07
4/8[b]	11.30	9.80	14.00	57	37.7	37.55
4/13[b]	9.90	8.10	14.00	31	30.1	43.60
4/14,17	10.75	9.40	13.30	72	42.6	46.00
4/18,20	10.30	8.50	11.80	38	34.5	48.65
4/21	9.95	9.00	11.50	24	27.6	50.26
4/22	8.45	7.70	10.50	18	35.3	50.22
4/23	8.70	7.40	13.00	22	39.3	54.25
4/24,25,26	7.00	6.20	9.40	29	43.9	54.42
5/1	8.60	6.30	13.40	22	34.4	77.26
5/2	6.40	5.10	8.20	29	31.9	76.86
5/7[c]	23.10	0.00	0.00	1	100.0	58.69
5/10,11,12, 13,14	6.65	4.70	8.00	16	32.0	59.83
5/19[c]	20.80	0.00	0.00	1	100.0	50.61
5/21[c]	27.30	0.00	0.00	1	33.3	43.67
5/23[c]	3.60	0.00	0.00	1	100.0	51.88
6/9[c]	6.90	0.00	0.00	1	50.0	27.08
7/4[c]	20.90	0.00	0.00	1	100.0	28.67
7/6[c]	20.80	0.00	0.00	1	100.0	26.84

[a] Confidence intervals calculated with nonparametric statistics.
[b] Purse seine tagging groups.
[c] Not used in statistical analysis because analysis showed too few recaptures.

$$\ln (\text{migration rate}) = -1.131 + 0.725 \ln (\text{mean discharge}).$$

The resulting r^2 shows there is a strong relation between migration rate and discharge. As discharge increases migration rate increases.

In 1992, chinook salmon smolts were PIT-tagged at the Clearwater River trap to provide travel time information through Lower Granite Reservoir for Clearwater River chinook salmon. Fifty daily groups (totaling 6,661 chinook salmon) were released from the Clearwater River trap from March 20 through May 1, May 6, and from May 18 through June 6 (Table 9). The linear regression analysis of the Clearwater River chinook salmon PIT-tag data showed a correlation between migration rate and discharge. ($r^2=0.242$, $N=50$, $P<0.001$). The regression equation after stratifying by 5-kcfs groups was not significant ($r^2=0.301$, $N=10$, $P<0.100$):

$$\ln (\text{migration rate}) = -1.033 + 0.657 \ln (\text{mean discharge}).$$

The chinook salmon migration rate/discharge relation for Snake River trap PIT-tag groups was examined to determine if there was a difference in this relation between years (1988-1992). The analysis of covariance was used with the data averaged by 5-kcfs groups. The analysis showed a significant difference in the migration rate/discharge relation between years (slope of the lines) at the 0.05 level of significance ($F=10.481$, $N=47$, $P<0.001$). A graph of the data showed that 1989 data had a slightly steeper slope (Figure 8). After removing the 1989 data, the analysis was re-run. A significant difference in the slopes could not be detected at the 0.05 level of significance ($F=1.019$, $N=37$, $P=0.399$). The analysis of covariance waa continued to test for a difference in the height of the lines for the four years of data. Again, no difference could be detected ($F=2.665$, $N=37$, $P=0.064$), indicating a common migration rate/discharge relation for chinook salmon for the four years. The four years of data (1988 and 1990-1992) were combined and the linear regression analysis was run. The regression equation on the combined data was significant ($r^2=0.864$, $N=37$, $P<0.001$):

$$\ln (\text{migration rate}) = -3.489 + 1.311 \ln (\text{mean discharge}).$$

Comparing the 1988 through 1992 migration rate/discharge equations for chinook, it becomes very apparent that in the discharge range for the available data, between 30 and 120 kcfs, all years showed the same basic relation (Figure 8). As discharge increases, migration rate increases. The amount of increase between 60 and 100 kcfs is consistent for 1988 and 1990-1992 (two-fold), but slightly higher for 1989 (three-fold). The same trend exists in all five years; increased flow in Lower Granite Reservoir increases migration rate through the reservoir.

Interrogation data for chinook tagged at the Snake River trap daily was limited to a narrow period (12 d) during the peak discharge for the season (Table 10). Because this data does not adequately represent the total migration season, cumulative interrogation data will not be reported for chinook salmon tagged at the Snake River trap for 1992.

Interrogation rate of Clearwater River trap daily release groups for PIT-tagged chinook salmon at Lower Granite Dam, after combining to remove groups with too small a sample size, ranged between 24.6% and 42.4% (Table 11). Seasonal cumulative interrogations of PIT-tagged chinook salmon from the Clearwater River trap to Lower Granite Dam was 32.4%. Cumulative interrogation, including Lower Granite, Little Goose Dam, and McNary Dam, ranged between 29.3% and 70.0%.

Table 9. PIT-tagged chinook salmon travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval [a] Upper	Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
3/20,21	24.15	21.30	26.10	36	37.5	30.13
3/22	26.10	24.60	28.10	56	37.1	31.37
3/23	25.00	23.50	27.50	52	34.7	31.51
3/24	24.30	22.60	28.10	48	32.0	31.63
3/25	24.00	21.60	27.20	38	25.3	32.06
3/26	21.30	16.50	22.50	26	27.7	31.53
3/27	20.35	18.20	26.70	28	26.7	31.79
3/28	21.35	18.60	25.20	24	40.0	32.88
3/29	20.25	17.30	23.00	40	30.1	33.18
3/30	17.40	15.20	23.50	33	31.7	32.68
3/31	18.10	15.80	22.60	33	24.6	33.89
4/1	18.50	15.00	22.40	31	36.0	35.79
4/2	14.05	13.60	15.90	34	33.0	33.96
4/3	14.85	13.10	18.70	52	33.5	35.22
4/4	12.95	11.60	14.20	60	39.0	35.21
4/5	13.90	11.30	17.00	57	38.0	36.69
4/6	15.20	12.70	17.20	50	33.3	38.12
4/7	16.30	15.00	21.50	53	34.2	39.59
4/8	20.80	15.00	22.50	49	32.5	42.92
4/9	17.40	13.20	20.50	41	27.2	42.82
4/10	19.65	16.30	21.00	58	38.4	44.60
4/11	21.50	17.00	22.70	52	34.7	49.13
4/12	19.95	17.60	21.40	50	33.3	48.04
4/13	19.10	16.10	21.60	39	25.8	48.64
4/14	17.80	16.60	19.60	59	39.3	49.27
4/15	15.90	14.80	17.50	45	30.0	47.90
4/16	20.00	16.60	24.70	45	30.0	55.94
4/17	16.90	15.40	18.60	51	33.8	54.43
4/18	18.60	14.90	20.60	49	32.5	58.60
4/19	16.80	13.30	21.10	48	32.0	58.20
4/20	17.00	12.60	20.50	46	30.7	59.82
4/21	13.70	11.40	17.80	43	28.7	58.50
4/22	11.15	10.00	12.70	56	37.3	56.61
4/23	10.25	9.70	12.30	56	37.3	57.06
4/24	12.10	9.10	15.10	40	29.9	62.07
4/25,26,27	10.90	7.60	13.20	43	30.9	65.47
4/28	12.40	11.80	13.20	47	31.1	71.10
4/29	11.10	6.70	12.90	42	28.2	73.01
4/30-5/1	11.10	9.60	13.80	67	34.4	75.08
5/6	8.20	5.30	9.90	50	33.3	67.82
5/18,19	6.10	4.60	8.10	35	27.6	52.27
5/20	7.20	6.40	8.70	23	26.4	53.19
5/24,25	4.70	4.10	6.20	48	32.7	54.42
5/26	7.20	4.10	10.60	34	35.4	52.54
5/27	9.20	5.10	9.80	26	33.3	49.21
5/28	7.05	5.00	10.00	38	26.6	48.83
5/29	5.70	4.00	8.20	19	31.1	47.49
5/30	5.05	4.10	6.70	42	42.4	46.54
5/31-6/1,2	6.50	5.70	7.70	44	30.1	46.81
6/3,4,5,6	9.95	4.70	15.10	20	26.7	38.25

[a] Confidence intervals calculated with nonparametric statistics.

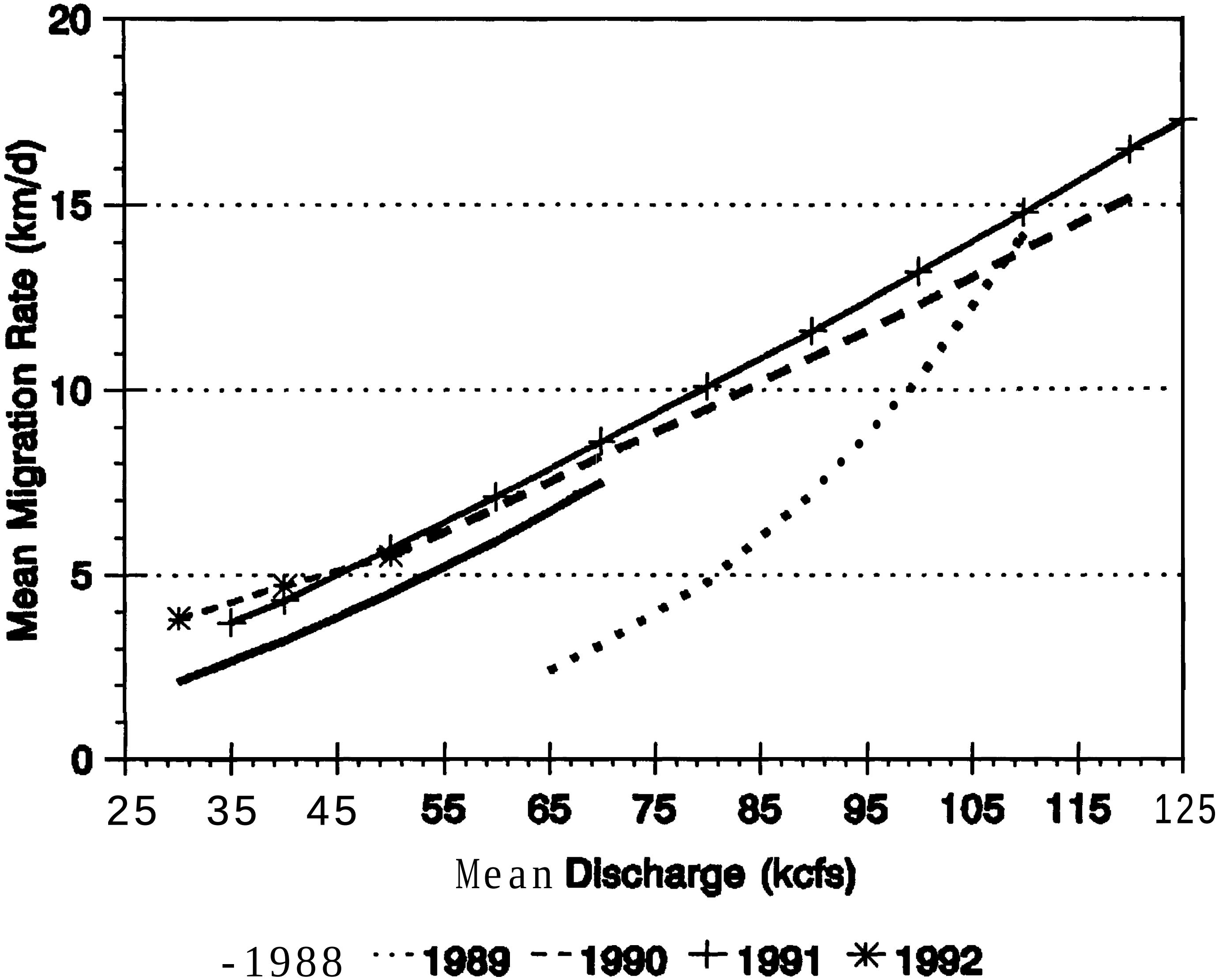

Figure 8. **Chinook salmon migration rate/discharge relations for Snake River trap PIT-tag groups, 1988-1992.**

Table 10. PIT-tagged chinook salmon interrogations at Lower Granite, Little Goose, and McNary dams from the Snake River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
4/14	150	64	42.7	24	16.0	11	7.3	99	66.0
4/17	19	8	42.1	2	10.5	0	0.0	10	52.6
4/18	83	28	33.7	13	15.7	13	15.7	54	65.1
4/20	27	10	37.0	2	7.4	4	14.8	16	59.3
4/21	87	24	27.6	15	17.2	8	9.2	47	54.0
4/22	51	18	35.3	11	21.6	8	15.7	37	72.5
4/23	56	22	39.3	11	19.6	4	7.1	37	66.1
4/24	32	10	31.2	4	12.5	6	18.8	20	62.5
4/25	23	13	56.5	2	8.7	3	13.0	18	78.3
4/26	10	6	60.0	1	10.0	2	20.0	9	90.0
5/1	64	22	34.4	12	18.8	6	9.4	40	62.5
5/2	75	24	32.0	8	10.7	7	9.3	39	52.0
5/6	16	5	31.2	3	18.8	3	18.8	11	68.8
5/7	1	1	--	0	--	0	--	1	--
5/10	17	5	29.4	2	11.8	1	5.9	8	47.1
5/11	10	4	40.0	2	20.0	1	10.0	7	70.0
5/12	7	2	--	1	--	0	--	3	--
5/13	7	3	--	3		0	--	6	--
5/14	9	2	--	0	--	0	--	2	--
5/18	2	0	--	0	--	1	--	1	--
5/19	1	1	--	0	--	0	--	1	--
5/21	3	1	--	0	--	0	--	1	--
5/22	2	0	--	0	--	0	--	0	--
5/23	1	1	--	0	--	0	--	1	--
5/29	1	0	--	0		0	--	0	--
6/2	2	0	--	0		0	--	0	
	1	0	--	0		0	--	0	
6/9	2	1	--	0	--	0	--	1	--
6/10	2	0	--	0	--	0	--	0	--
7/4	1	1	--	0	--	0	--	1	--
7/6	1	1	--	0	--	0	--	1	--
Total	763	277		116		78		471	

Table 11. PIT-tagged chinook salmon interrogations at Lower Granite, Little Goose, and McNary dame from the Clearwater River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
3/20	36	14	38.9	5	13.9	5	13.9	24	66.7
3/21	60	22	36.7	10	16.7	5	8.3	37	61.7
3/22	151	56	37.1	20	13.2	17	11.3	93	61.6
3/23	150	52	34.7	29	19.3	11	7.3	92	61.3
3/24	150	48	32.0	27	18.0	14	9.3	89	59.3
3/25	150	38	25.3	27	18.0	11	7.3	76	50.7
3/26	94	26	27.7	12	12.8	8	8.5	46	48.9
3/27	105	28	26.7	21	20.0	11	10.5	60	57.1
3/28	60	24	40.0	10	16.7	8	13.3	42	70.0
3/29	133	40	30.1	22	16.5	17	12.8	79	59.4
3/30	104	33	31.7	20	19.2	9	8.7	62	59.6
3/31	134	33	24.6	24	17.9	16	11.9	73	54.5
4/1	86	31	36.0	19	22.1	4	4.7	54	62.8
4/2	103	34	33.0	18	17.5	8	7.8	60	58.3
4/3	155	52	33.5	24	15.5	17	11.0	93	60.0
4/4	154	60	39.0	20	13.0	11	7.1	91	59.1
4/5	150	57	38.0	31	20.7	11	7.3	99	66.0
4/6	150	50	33.3	31	20.7	12	8.0	93	62.0
4/7	155	53	34.2	25	16.1	10	6.5	88	56.8
4/8	151	49	32.5	23	15.2	14	9.3	86	57.0
4/9	151	41	27.2	24	15.9	15	9.9	80	53.0
4/10	151	58	38.4	22	14.6	10	6.6	90	59.6
4/11	150	52	34.7	26	17.3	8	5.3	86	57.3
4/12	150	50	33.3	26	17.3	12	8.0	88	58.7
4/13	151	39	25.8	19	12.6	22	14.6	80	53.0
4/14	150	59	39.3	25	16.7	13	8.7	97	64.7
4/15	150	45	30.0	16	10.7	11	7.3	72	48.0
4/16	150	45	30.0	18	12.0	10	6.7	73	48.7
4/17	151	51	33.8	16	10.6	18	11.9	85	56.3
4/18	151	49	32.5	16	10.6	17	11.3	82	54.3
4/19	150	48	32.0	18	12.0	17	11.3	83	55.3
4/20	150	46	30.7	16	10.7	13	8.7	75	50.0
4/21	150	43	28.7	28	18.7	6	4.0	77	51.3
4/22	150	56	37.3	20	13.3	11	7.3	87	58.0
4/23	150	56	37.3	20	13.3	18	12.0	94	62.7
4/24	134	40	29.9	20	14.9	18	13.4	78	58.2
4/25	63	19	30.2	8	12.7	6	9.5	33	52.4
4/26	50	15	30.0	4	8.0	4	8.0	23	46.0
4/27	26	9	34.6	6	23.1	2	7.7	17	65.4
4/28	151	47	31.1	12	7.9	14	9.3	73	48.3
4/29	149	42	28.2	26	17.4	19	12.8	87	58.4
4/30	150	56	37.3	24	16.0	17	11.3	97	64.7
5/1	45	11	24.4	5	11.1	6	13.3	22	48.9
5/6	150	50	33.3	16	10.7	18	12.0	84	56.0
5/18	38	13	34.2	4	10.5	3	7.9	20	52.6
5/19	89	22	24.7	7	7.9	7	7.9	36	40.4
5/20	87	23	26.4	8	9.2	7	8.0	38	43.7
5/24	91	32	35.2	10	11.0	3	3.3	45	49.5
5/25	56	16	28.6	2	3.6	0	0.0	18	32.1
5/26	96	34	35.4	16	16.7	2	2.1	52	54.2
5/27	78	26	33.3	6	7.7	3	3.8	35	44.9
5/28	143	38	26.6	20	14.0	3	2.1	61	42.7
5/29	61	19	31.1	5	8.2	6	9.8	30	49.2
5/30	99	42	42.4	10	10.1	3	3.0	55	55.6

Table 11. Continued.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
5/31	48	14	29.2	2	4.2	1	2.1	17	35.4
6/1	58	20	34.5	3	5.2	2	3.4	25	43.1
6/2	40	10	25.0	3	7.5	1	2.5	14	35.0
6/3	30	7	23.3	0	0.0	0	0.0	7	23.3
6/4	19	5	26.3	1	5.3	0	0.0	6	31.6
6/5	25	7	28.0	1	4.0	0	0.0	8	32.0
6/6	1	1	--	0	--	0	--	1	--
Total	6663	2156		947		565		3660	

Hatchery Steelhead Trout PIT-Tao Groups-Sufficient numbers of hatchery steelhead trout were PIT-tagged daily at the Snake River trap to provide 43 daily release groups (3,904 individual fish) to be used in median migration rate calculations through Lower Granite Reservoir. Median travel time ranged from 22.9 to 3.5 d (2.3 km/d to 16.0 km/d migration rate) and averaged 8.5 d (6.1 km/d), which was about two times slower than in 1990 and 1991 (Table 12).

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite discharge (inflow) for PIT-tagged hatchery steelhead trout groups (r^2=0.671, N=43, P<0.001). The best linear regression equation was:

$$\ln \text{(migration rate)} = -2.155 + 1.040 \ln \text{(mean discharge)}.$$

The linear regression equation for the daily release groups stratified into 5-kcfs discharge intervals was (r^2=0.844, N=10, P<0.001):

$$\ln \text{(migration rate)} = -2.208 + 1.048 \ln \text{(mean discharge)}.$$

The equation shows that, as discharge increases, migration rate increases for PIT-tagged hatchery steelhead trout marked at the Snake River trap.

Twenty-seven groups of hatchery steelhead trout (1,567 individual fish) were PIT-tagged at the Clearwater River trap in 1992 for use in median migration rate calculations through Lower Granite Reservoir (Table 13). Median travel time ranged from 25.2 to 4.0 d (2.4 km/d to 15.4 km/d) and averaged 9.3 d (6.6 km/d). The average hatchery steelhead took about 2 days longer in 1992 to reach Lower Granite Dam than in 1991. Average inflow discharge to Lower Granite Reservoir during the migration season was 54.0 kcfs and ranged from 31.4 to 78.2 kcfe.

The linear regression analysis detected a significant relation between migration rate in Lower Granite Reservoir and average Lower Granite inflow discharge for Clearwater River PIT-tagged hatchery steelhead trout (r^2=0.541, N=27, P=0.001). Further analysis of the data, stratified by 5-kcfs discharge groups, likewise detected a significant relation between discharge and migration rate after stratification (r^2=0.796, N=ll, P<0.001):

$$\ln \text{(migration rate)} = -2.769 + 1.182 \ln \text{(mean discharge)}.$$

Hatchery steelhead trout migration rate/discharge relation among years for fish PIT-tagged at the Snake River trap was examined to see if the relation was constant over years. Analysis of covariance on the log transformed data was used to determine if there was a significant difference between years (1988-1992) in migration rate averaged by 5-kcfs intervals. A significant difference among years (elopes of the lines) was detected for the hatchery steelhead trout migration rate/discharge relation at the 0.05 level of significance (F=4.476, N=59, P=0.004). A graph of the data showed that the 1988 and 1992 data had a slightly more gradual slope than the other three years data (Figure 9). The analysis of covariance was run on the four years data, omitting first the 1992 data (1988-1991) and then the 1988 data (1989-1992). When the analysis of covariance was run on the 1988-1991 data set, a significant difference could no longer be detected. When the 1988 data were removed (1989-1992 data) the analysis of covariance still detected a significant difference between years, indicating that 1992 was the year that was significantly different. The analysis

Table 12. PIT-tagged hatchery eteelhead travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval [a] Upper	Confidence Interval [a] Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
4/17	9.90	7.70	13.60	34	54.0	48.22
4/18	10.40	7.90	11.70	36	60.0	48.65
4/19	8.05	6.10	11.30	36	59.0	49.16
4/20	9.60	6.80	11.30	45	71.4	49.00
4/21	9.55	8.10	10.60	44	73.3	50.26
4/22	8.70	8.20	9.30	47	78.3	51.06
4/23	8.60	7.30	10.20	39	65.0	54.25
4/24	7.65	6.70	9.90	46	76.7	54.02
4/25	6.10	5.80	7.10	47	77.0	50.03
4/26	6.40	5.50	7.20	42	70.0	55.31
4/27	5.40	4.50	7.00	41	68.3	56.68
4/28	5.30	4.10	6.00	45	75.0	64.19
4/29	3.85	3.10	5.00	42	70.0	67.72
4/30	3.50	2.70	4.40	42	70.0	74.56
5/1	4.45	4.00	5.10	48	80.0	79.09
5/2	3.80	3.00	5.50	41	68.3	78.19
5/3	3.75	3.10	5.00	42	70.0	76.49
5/4	4.65	3.60	5.80	46	76.7	75.50
5/5	3.70	3.10	5.00	43	71.7	75.41
5/6	6.90	4.10	9.80	33	55.0	70.66
5/7	7.80	4.20	8.30	33	55.0	66.48
5/8	6.90	6.60	8.80	36	60.0	65.57
5/9	6.10	5.70	11.80	27	45.0	63.82
5/10	5.80	4.90	11.00	27	44.3	62.23
5/11	9.90	5.70	11.60	23	38.3	56.06
5/12	7.10	4.80	10.70	27	45.0	56.77
5/13,14	9.10	7.80	13.70	39	32.8	55.49
5/15	7.45	6.70	9.10	20	33.3	55.23
5/16,17	6.80	5.90	7.80	29	35.8	51.15
5/18,19	4.00	3.10	7.90	31	39.7	52.80
5/20	5.20	4.00	11.60	23	38.3	53.44
5/21	7.00	5.90	26.80	23	38.3	54.45
5/22,23,24	7.80	5.30	16.40	40	28.4	53.36
5/27,28,29	9.40	5.10	23.20	29	28.2	48.24
5/30,31-6/1,2	22.85	13.70	27.60	44	18.6	32.98
6/3[b]	6.60	0.00	0.00	1	33.3	47.03
6/4[b]	28.70	0.00	0.00	2	20.0	28.01
6/5,6,7	14.95	6.70	18.20	26	14.4	31.05
6/8,9,10,11	17.90	15.80	21.90	29	26.1	23.38
6/12,14,15	14.95	14.10	17.10	30	19.7	23.00
6/17,18,19	12.10	8.60	18.10	31	17.1	22.61
6/20,21,22,23	11.30	9.80	20.70	25	10.3	20.97
6/24,25,26,27	10.80	7.90	14.10	24	10.3	26.21
6/30-7/1,3	17.00	5.80	30.10	22	13.5	31.04
7/4,5,6,7	13.20	6.80	30.80	16	13.3	33.71

'Confidence intervals calculated with nonparametric statistics.
[b] **Not** used in statistical analysis because analysis showed too few recaptures.

Table 13. PIT-tagged hatchery steelhead trout travel time, with 95% confidence intervals, from the Clearwater River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval [a] Upper	Confidence Interval [a] Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
4/22	10.30	9.00	12.00	33	55.0	54.03
4/23	9.50	8.10	10.90	48	80.0	57.06
4/24	8.65	7.10	10.50	40	66.7	57.17
4/25	7.90	7.00	8.90	47	78.3	57.91
4/26	7.70	6.50	9.50	45	75.0	61.45
4/27	7.00	5.70	8.90	43	71.7	63.30
4/28	5.95	5.00	6.20	42	70.0	66.38
4/29	5.00	4.00	5.80	47	75.8	69.65
4/30	4.45	3.90	5.90	40	63.5	74.56
5/1	6.40	5.50	8.20	38	62.3	78.18
5/3	8.90	7.60	10.10	39	65.0	74.56
5/6	8.50	5.10	10.80	35	57.4	67.49
5/18	5.65	4.90	6.10	36	60.0	51.28
5/19	3.95	3.20	5.00	40	65.6	52.80
5/20	5.40	4.10	7.90	33	54.1	53.44
5/24	9.80	5.10	20.80	21	40.4	51.36
5/25	8.85	6.90	12.80	26	35.6	51.44
5/26	6.90	4.10	10.40	28	46.7	52.54
5/27	6.70	4.90	10.80	26	43.3	51.12
5/28	8.15	5.10	26.80	24	42.9	47.93
5/29	9.35	4.80	28.20	16	43.2	47.63
5/30	25.20	4.00	33.30	11	29.7	34.31
5/31-6/1	10.50	5.90	36.00	14	19.7	44.85
6/2	23.60	18.40	32.90	10	20.8	31.39
6/3,4	6.90	4.40	20.50	20	29.0	47.03
6/5,6	10.85	3.20	23.70	10	28.6	35.52
6/12	19.30	7.70	25.60	11	18.6	22.84

[a] Confidence intervals calculated with nonparametric statistics.

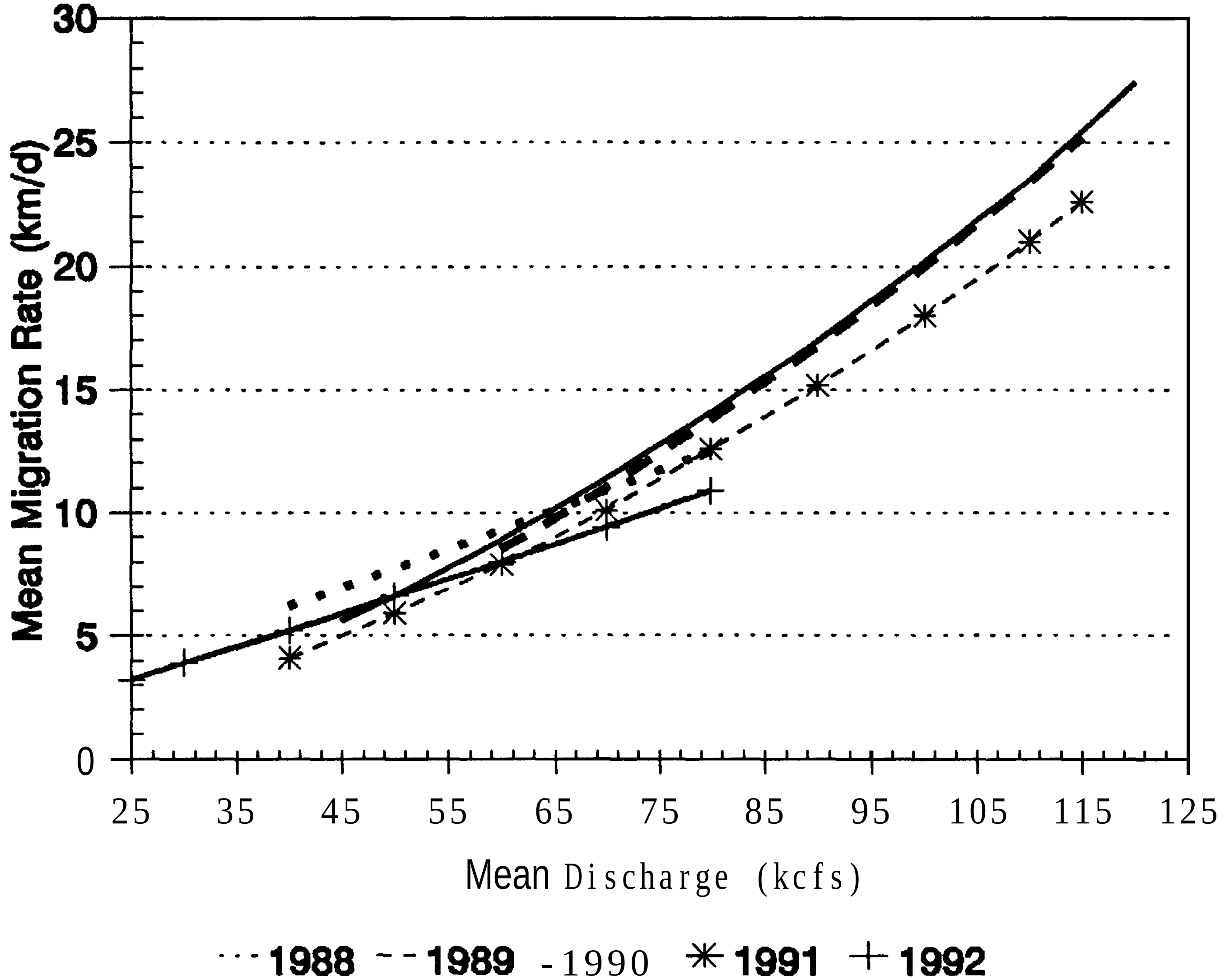

Figure 9. Hatchery steelhead trout migration rate/discharge relations for Snake River trap PIT-tag groups, 1988-1992.

was continued using 1988-1991 to determine if the intercepts (heights) of the lines were different. Analysis was unable to detect a significant difference in the intercepts of the lines. The 1988 through 1991 data were pooled and the linear regression analysis conducted (r^2=0.909, N=49, P<0.001):

$$\ln \text{(migration rate)} = -4.092 + 1.531 \ln \text{(mean discharge)}.$$

PIT-tagged hatchery steelhead trout from the Snake River trap move more than five times faster through Lower Granite Reservoir at 120 kcfs as they do at 40 kcfs. Not only is the migration rate/discharge relation for these fish consistent during the outmigration season, but is also consistent year to year.

Percent interrogation of Snake River trap hatchery steelhead trout daily PIT-tag release groups at Lower Granite Dam, after combining to remove groups with small sample size, ranged from 10.3% to 93.3% (Table 14). Seasonal cumulative interrogation rate of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 38.3%, to Little Goose Dam 44.1%, and to McNary Dam 44.9%. The cumulative interrogation rate for 1992 was half of the previous year's rate. Lack of flow in Lower Granite Reservoir during the majority of the hatchery steelhead outmigration caused the fish to stall in the reservoir. As temperatures increased during June and July, many of these fish died or residualized. Large numbers of hatchery steelhead remained in the head of the reservoir, and the Snake River trap collected fish for about three weeks longer than in other years. Interrogation rate at the three recovery dams was very low for these late groups tagged after mid-June (less than 20%). If interrogation rate is compared over a similar time period for 1991 and 1992, the cumulative interrogation for 1992 increases to 55%, which is still about 40% lower than in 1991.

Interrogation rates at Lower Granite, Little Goose, and McNary dams combined, for Clearwater River trap hatchery steelhead trout daily PIT-tag release groups, ranged from 21.1% to 90.0% (Table 15). The cumulative interrogation rate of PIT-tagged hatchery steelhead trout to Lower Granite Dam was 52.5%, to Little Goose Dam 60.0%, and to McNary Dam 60.4%. The cumulative interrogation rate of 60.4% for hatchery steelhead tagged at the Clearwater River trap was 35% greater than the cumulative interrogation rate for Snake River trap hatchery steelhead (44.9%). In 1991, the reverse was seen when interrogations of Snake River trap fish were 7.7% higher than interrogations for Clearwater River trap hatchery steelhead. The major difference between the two years is hatchery steelhead were tagged for three weeks longer at the Snake River trap than at the Clearwater River trap in 1992, and the interrogation rate for these later groups was very low (10.3% – 19.3%).

<u>Wild Steelhead Trout PIT-Tag Groups</u>-Sufficient numbers of wild steelhead trout were PIT-tagged at the Snake River trap to provide 27 daily release groups (2,538 individual fish) for estimating travel time and migration rate in Lower Granite Reservoir (Table 16). Median travel time ranged from 6.1 d (8.5 km/d) to 2.7 d (19.1 km/d) and averaged 4.4 d (11.7 km/d). Linear regression analysis showed a strong significant relation between median migration rate in Lower Granite Reservoir and mean discharge for PIT-tagged wild steelhead trout groups (r^2=0.590, N=27, P<0.001). The best linear regression equation was:

$$\ln \text{(migration rate)} = -1.678 + 1.014 \ln \text{(mean discharge)}.$$

Ss discharge increases, migration rate in Lower Granite Reservoir increases.

Table 14. PIT-tagged hatchery steelhead interrogations at Lower Granite, Little Goose, and McNary dams from the Snake River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
4/17	63	34	54.0	6	9.5	2	3.2	42	66.7
4/18	60	36	60.0	6	10.0	1	1.7	43	71.7
4/19	61	36	59.0	11	18.0	1	1.6	48	78.7
4/20	63	45	71.4	10	15.9	0	0.0	55	87.3
4/21	60	44	73.3	9	15.0	0	0.0	53	88.3
4/22	60	47	78.3	9	15.0	0	0.0	56	93.3
4/23	60	39	65.0	12	20.0	0	0.0	51	85.0
4/24	60	46	76.7	6	10.0	0	0.0	52	86.7
4/25	61	47	77.0	8	13.1	0	0.0	55	90.2
4/26	60	42	70.0	6	10.0	0	0.0	48	80.0
4/27	60	41	68.3	10	16.7	1	1.7	52	86.7
4/28	60	45	75.0	10	16.7	0	0.0	55	91.7
4/29	60	42	70.0	9	15.0	2	3.3	53	88.3
4/30	60	42	70.0	10	16.7	0	0.0	52	86.7
5/1	60	48	80.0	5	8.3	2	3.3	55	91.7
5/2	60	41	68.3	6	10.0	0	0.0	47	78.3
5/3	60	42	70.0	7	11.7	0	0.0	49	81.7
5/4	60	46	76.7	1	1.7	0	0.0	47	78.3
5/5	60	43	71.7	3	5.0	0	0.0	46	76.7
5/6	60	33	55.0	11	18.3	0	0.0	44	73.3
5/7	60	33	55.0	2	3.3	1	1.7	36	60.0
5/8	60	36	60.0	2	3.3	0	0.0	38	63.3
5/9	60	27	45.0	0	0.0	0	0.0	27	45.0
5/10	61	27	44.3	6	9.8	1	1.6	34	55.7
5/11	60	23	38.3	5	8.3	0	0.0	28	46.7
5/12	60	27	45.0	2	3.3	1	1.7	30	50.0
5/13	60	23	38.3	2	3.3	2	3.3	27	45.0
5/14	59	16	27.1	2	3.4	1	1.7	19	32.2
5/15	60	20	33.3	5	8.3	1	1.7	26	43.3
5/16	30	12	40.0	1	3.3	1	3.3	14	46.7
5/17	51	17	33.3	5	9.8	1	2.0	23	45.1
5/18	18	3	16.7	1	5.6	0	0.0	4	22.2
5/19	60	28	46.7	6	10.0	0	0.0	34	56.7
5/20	60	23	38.3	1	1.7	2	3.3	26	43.3
5/21	60	23	38.3	4	6.7	1	1.7	28	46.7
5/22	60	19	31.7	2	3.3	1	1.7	22	36.7
5/23	59	17	28.8	3	5.1	0	0.0	20	33.9
5/24	22	4	18.2	2	9.1	0	0.0	6	27.3
5/27	19	4	21.1	2	10.5	0	0.0	6	31.6
5/28	60	16	26.7	3	5.0	2	3.3	21	35.0
5/29	24	9	37.5	0	0.0	0	0.0	9	37.5
5/30	60	10	16.7	0	0.0	0	0.0	10	16.7
5/31	65	11	16.9	2	3.1	1	1.5	14	21.5
6/1	52	8	15.4	1	1.9	0	0.0	9	17.3
6/2	60	15	25.0	1	1.7	3	5.0	19	31.7
6/3	3	1	--	0	--	0	--	1	--
6/4	10	2	20.0	1	10.0	0	0.0	3	30.0
6/5	62	9	14.5	0	0.0	0	0.0	9	14.5
6/6	60	12	20.0	0	0.0	0	0.0	12	20.0
6/7	59	5	8.5	0	0.0	0	0.0	5	8.5
6/8	24	3	12.5	0	0.0	0	0.0	3	12.5
6/9	19	9	47.4	0	0.0	0	0.0	9	47.4
6/10	9	3	--	1	--	0	--		--
6/11	59	14	23.7	1	1.7	0	0.0	1:	25.4
6/12	60	12	20.0	1	1.7	1	1.7	14	23.3

Table 14. Continued.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
6/14	31	8	25.8	0	0.0	0	0.0	8	25.8
6/15	61	10	16.4	2	3.3	0	0.0	12	19.7
6/17	60	16	26.7	3	5.0	0	0.0	19	31.7
6/18	59	6	10.2	1	1.7	0	0.0	7	11.9
6/19	62	9	14.5	0	0.0	0	0.0	9	14.5
6/20	60	5	8.3	0	0.0	0	0.0	5	8.3
6/21	62	6	9.7	1	1.6	0	0.0	7	11.3
6/22	60	6	10.0	0	0.0	0	0.0	6	10.0
6/23	60	8	13.3	1	1.7	0	0.0	9	15.0
6/24	61	6	9.8	0	0.0	0	0.0	6	9.8
6/25	60	4	6.7	0	0.0	0	0.0	4	6.7
6/26	59	8	13.6	0	0.0	0	0.0	8	13.6
6/27	53	6	11.3	0	0.0	0	0.0	6	11.3
6/30	60	11	18.3	0	0.0	0	0.0	11	18.3
7/1	60	5	8.3	0	0.0	0	0.0	5	8.3
7/3	43	6	14.0	0	0.0	0	0.0	6	14.0
7/4	62	7	11.3	0	0.0	1	1.6	8	12.9
7/5	40	7	17.5	0	0.0	0	0.0		17.5
7/6	12	1	8.3	0	0.0	0	0.0	I	8.3
7/7	6	1	--	0	--	0	--	1	--
Total	3904	1496		227		30		1753	

Table 15. PIT-tagged hatchery ateelhead interrogations at Lower Granite, Little Goose, and McNary dams from the Clearwater River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
4/2	1	0	--	0	--	0	--	0	--
4/22	60	33	55.0	13	21.7	0	0.0	46	76.7
4/23	60	48	80.0	6	10.0	0	0.0	54	90.0
4/24	60	40	66.7	8	13.3	1	1.7	49	81.7
4/25	60	47	78.3	7	11.7	0	0.0	54	90.0
4/26	60	45	75.0	3	5.0	0	0.0	48	80.0
4/27	60	43	71.7	4	6.7	0	0.0	47	78.3
4/28	60	42	70.0	7	11.7	0	0.0	49	81.7
4/29	62	47	75.8	4	6.5	0	0.0	51	82.3
4/30	63	40	63.5	6	9.5	0	0.0	46	73.0
5/1	61	38	62.3	5	8.2	1	1.6	44	72.1
5/3	60	39	65.0	8	13.3	0	0.0	47	78.3
5/6	61	35	57.4	4	6.6	0	0.0	39	63.9
5/18	60	36	60.0	4	6.7	0	0.0	40	66.7
5/19	61	40	65.6	5	8.2	0	0.0	45	73.8
5/20	61	33	54.1	4	6.6	0	0.0	37	60.7
5/24	52	21	40.4	3	5.8	0	0.0	24	46.2
5/25	73	26	35.6	1	1.4	1	1.4	28	38.4
5/26	60	28	46.7	2	3.3	0	0.0	30	50.0
5/27	60	26	43.3	4	6.7	2	3.3	32	53.3
5/28	56	24	42.9	2	3.6	0	0.0	26	46.4
5/29	37	16	43.2	1	2.7	0	0.0	17	45.9
5/30	37	11	29.7	3	8.1	1	2.7	15	40.5
5/31	41	8	19.5	0	0.0	0	0.0	8	19.5
6/1	30	6	20.0	1	3.3	0	0.0	7	23.3
6/2	48	10	20.8	2	4.2	0	0.0	12	25.0
6/3	37	14	37.8	2	5.4	0	0.0	16	43.2
6/4	32	6	18.8	1	3.1	0	0.0	7	21.9
6/5	32	9	28.1	4	12.5	0	0.0	13	40.6
6/6	3	1	--	1	--	0	--	2	--
6/12	59	11	18.6	3	5.1	0	0.0	14	23.7
Total	1567	823		118		6		947	

Table 16. PIT-tagged wild ateelhead trout travel time, with 95% confidence intervals, from the Snake River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval . Upper	Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
4/17,18	5.25	4.40	6.30	34	58.6	47.37
4/19	5.00	4.50	6.10	37	71.2	48.91
4/20	4.60	4.00	5.30	37	77.1	49.52
4/21	5.50	4.10	6.80	58	69.9	50.00
4/22	5.65	4.80	6.50	38	62.3	50.29
4/23	5.60	5.40	6.10	26	70.3	49.95
4/24	6.05	4.50	6.40	18	72.0	48.94
4/25	4.60	4.30	4.90	67	63.2	48.48
4/26,27	4.70	4.30	5.20	29	56.9	50.22
4/28	3.50	3.30	4.20	64	67.4	59.64
4/29	3.10	2.60	3.90	19	52.8	62.84
4/30	2.70	2.50	3.10	72	68.6	73.64
5/1	3.80	3.60	3.90	180	69.8	79.09
5/2	2.90	2.70	3.20	155	63.5	78.54
5/3	3.30	3.00	3.70	69	74.2	76.79
5/4	3.60	3.30	3.90	44	65.7	75.36
5/5	3.00	2.70	3.50	44	73.3	75.18
5/6	3.65	3.40	4.00	54	68.4	75.46
5/7	3.60	3.30	4.10	40	55.6	74.75
5/8	4.70	3.70	5.00	61	57.0	69.24
5/9	4.40	3.70	5.10	88	48.6	67.53
5/10	5.00	4.80	5.70	90	54.9	61.11
5/11	5.00	4.40	5.70	60	54.1	60.13
5/12	3.80	2.90	5.40	29	46.8	58.62
5/13,14,15	6.10	4.30	8.50	27	43.5	57.26
5/16,17,18,19	4.70	3.00	6.90	23	43.4	52.59
5/21,22,23	5.85	5.10	8.00	34	40.0	53.62
5/27[b]	34.70	0.00	0.00	2	66.6	33.44
5/28[b]	3.80	0.00	0.00	3	30.0	52.04
5/29[b]	2.60	0.00	0.00	1	33.3	50.42
5/31[b]	5.80	0.00	0.00	1	5.5	45.71
6/1[b]	6.00	0.00	0.00	1	50.0	46.23
6/2[b]	7.10	0.00	0.00	2	20.0	47.23
6/12[b]	7.80	0.00	0.00	1	25.0	24.84
6/22[b]	14.20	0.00	0.00	1	50.0	23.64
6/25[b]	9.70	0.00	0.00	1	33.3	22.77
7/5[b]	25.00	0.00	0.00	1	100.0	25.96

[a] Confidence intervals calculated with nonparametric statistics.
[b] Not used in statistical analysis because analysis showed too few recaptures.

Linear regression equation for PIT-tag groups stratified into 5-kcfs intervals (r^2=0.749, N=7, P=0.012) was:

$$\ln\text{ (migration rate)} = -1.769 + 1.029 \ln\text{ (mean discharge)}.$$

This indicates that 75% of the variation in migration rate is accounted for by changes in discharge. Migration rate is very dependent on discharge. The higher the discharge, the faster wild steelhead trout migrate.

Twenty-four wild steelhead trout PIT-tagged groups (2,996 individual fish) were released from the Clearwater River trap in 1992 for use in median migration rate calculations through Lower Granite Reservoir (Table 17). Median travel time ranged from 8.1 d to 3.5 d (7.6 to 17.6 km/d, respectively) and averaged 5.9 d (10.4 km/d). Average discharge for the PIT-tagged wild steelheadtrout migration season was 47.3 kcfs.

The linear regression analysis showed a significant relation between migration rate in Lower Granite Reservoir and average discharge into the reservoir for wild steelheadtrout groups released from the Clearwater River trap (r^2=0.746, N=24, P<0.001). The best linear regression equation was:

$$\ln\text{ (migration rate)} = -0.782 + 0.826 \ln\text{ (mean discharge)}.$$

The linear regression equation for PIT-tag groups stratified into 5-kcfs intervals (r^2=0.922, N=9, P<0.001) was:

$$\ln\text{ (migration rate)} = -1.211 + 0.932 \ln\text{ (mean discharge)}.$$

This indicates that 92% of the variation in wild steelhead trout migration rate for fish released from the Clearwater River trap is accounted for by changes in discharge. Reservoir inflow is a very important variable associated with the rate of movement of wild steelhead trout through the reservoir itself. As discharge increases, so does migration rate.

The wild steelhead trout migration rate/discharge relation for fish released from the Snake River trap was examined to see if this relation was constant over years. The analysis of covariance was used to determine if there was a significant difference among years (1988-1992) in migration rates using groups averaged by 5-kcfs intervals. Analysis showed no significant difference among years for the slopes of the wild steelhead trout migration rate/discharge relations (F=0.891, N=56, P=0.477), nor was there a significant difference in migration rate (intercept) between years (F=0.814, N=56, P=0.522). The data were pooled and the linear regression analysis was run using the log transformed data (r^2=0.845, N=56, P<0.001). The best linear regression equation was:

$$\ln\text{ (migration rate)} = -2.048 + 1.105 \ln\text{ (mean discharge)}.$$

The analysis indicates that 85% of the variation in migration rate for PIT-tagged wild steelhead trout released from the Snake River trap between 1988 and 1992 was accounted for by changes in discharge. A two-fold increase in discharge will increase migration rate 2.2 times.

Table 17. PIT-tagged wild steelhead trout travel time, with 95% confidence intervala, from the Clearwater River trap to Lower Granite Dam, 1992.

Release date	Median travel time (days)	Confidence Interval [a] Upper	Confidence Interval [a] Lower	Number captured at LGD	Percent captured	Mean discharge (kcfs)
3/22[b]	21.70	0.00	0.00	1	100.0	29.87
3/24[b]	9.30	0.00	0.00	1	50.0	27.01
3/27[b]	8.70	0.00	0.00	1	50.0	27.95
3/28[b]	20.10	0.00	0.00	1	50.0	32.50
3/29-31,4/1-3	7.10	5.70	7.70	29	61.7	31.68
4/4,5	6.30	5.80	8.00	36	43.4	31.99
4/6	7.50	7.00	8.40	63	38.4	33.54
4/7	8.10	7.10	9.00	47	50.0	34.31
4/8	7.65	7.00	8.30	38	39.2	35.46
4/9,10	7.10	5.80	9.20	27	47.4	36.25
4/11	5.90	5.40	6.10	72	46.8	38.80
4/12	6.70	5.70	7.50	76	58.9	40.60
4/13	6.00	5.50	6.90	30	57.7	41.26
4/14	5.90	5.20	7.10	33	49.3	43.07
4/15	5.70	4.90	6.20	33	38.8	43.96
4/16,17	5.70	4.60	6.20	23	47.9	44.29
4/18	6.10	5.80	6.80	73	50.0	48.81
4/19	5.70	5.60	6.10	301	55.8	49.29
4/20	5.80	5.20	6.50	99	52.7	49.44
4/21	6.65	5.50	7.00	50	54.9	49.26
4/22	6.40	5.40	7.10	35	50.0	50.29
4/23,24,25	6.20	5.30	7.40	22	53.7	48.94
4/26,27	5.00	4.40	6.30	17	54.8	50.22
4/28	4.30	3.70	4.60	56	54.4	59.64
4/29	3.50	3.20	3.80	132	65.0	67.72
4/30	3.60	3.30	3.90	230	63.4	74.56
5/1	3.90	3.60	4.50	27	67.5	79.09
5/3[b]	5.00	0.00	0.00	1	33.3	75.75
5/6[b]	6.00	0.00	0.00	2	66.7	73.45
5/18,19,20	3.85	3.20	5.20	20	48.8	52.80
5/24[b]	7.80	0.00	0.00	3	37.5	52.92
5/25[b]	4.00	0.00	0.00	5	31.2	55.36
5/26[b]	5.95	0.00	0.00	4	36.4	53.65
5/29[b]	11.65	0.00	0.00	4	57.1	47.56
5/30[b]	8.90	0.00	0.00	2	66.7	47.41
5/31[b]	7.10	0.00	0.00	1	16.7	46.52
6/1[b]	34.80	0.00	0.00	2	25.0	29.89
6/3[b]	8.00	0.00	0.00	1	33.3	44.36
6/12[b]	69.70	0.00	0.00	1	14.3	21.06

[a] Confidence intervals calculated with nonparametric statictics.
[b] Not used in statistical analysis because analysis showed too few recaptures

The combined interrogation rate at Lower Granite, Little Goose, and McNary dams for wild steelhead trout PIT-tag groups released daily from the Snake River trap ranged from 47.1% to 92.0% (Table 18). Cumulative interrogation rate of PIT-tagged wild steelhead trout to Lower Granite Dam was 59.5%, to Little Goose Dam 71.6%, and to McNary Dam 72.9%. The interrogation rate at the three dams for PIT-tagged wild steelhead trout was about 38% higher than the interrogation rate for hatchery steelhead trout marked at the Snake River trap. Interrogation rates for hatchery and wild steelhead trout marked at the Clearwater River trap were 60.4% and 73.1%, respectively. The cumulative interrogation rates at the three dams for chinook salmon and hatchery and wild steelhead trout tagged at each trap were considerably lower in 1992 than in 1991.

The combined interrogation rates at Lower Granite, Little Goose, and McNary for daily wild steelhead trout PIT-tag groups released from the Clearwater River trap at Lower Granite Dam ranged from 53.7% to 85.0% (Table 19). Cumulative interrogation rate of PIT-tagged wild steelhead trout released at the Clearwater River trap to Lower Granite Dam was 53.4%, to Little Goose Dam was 69.3%, and to McNary Dam was 73.1%.

Head of Lower Granite Reservoir to Little Goose Dam

Chinook Salmon PIT-Tas Groups-The relation between migration rate and discharge was examined for PIT-tagged chinook salmon from point of release at the head of Lower Granite Reservoir to interrogation at Little Goose Dam. Not enough chinook salmon were tagged at the Snake River trap in 1992 to examine the relation. The same analysis was conducted on the PIT-tagged chinook salmon data from the Clearwater River trap (Table 20). This analysis showed that 70% of the variation in the migration rate for chinook salmon from the Clearwater River trap to Little Goose Dam was accounted for by discharge (r^2=0.699, N=9, P=0.005).

Hatchery Steelhead Trout PIT-Taq Groups-The migration rate/discharge relation for PIT-tagged hatchery steelhead trout released from the Snake River trap and interrogated at Little Goose Dam was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals (Table 21) and log transformed. Ninety-one percent of the variation in migration rate for PIT-tagged hatchery steelhead trout from the Snake River trap is accounted for by discharge (r^2=0.910, N=9, P<0.012). The same analysis was conducted for hatchery steelhead trout PIT-tagged at the Clearwater River trap and interrogated at Little Goose Dam. The analysis described a strong correlation between migration rate and discharge (r^2=0.818, N=7, P=0.005).

Wild Steelhead Trout PIT-Tas Groups-The migration rate/discharge relation for wild steelhead trout PIT-tagged and released from the Snake River trap was examined using the linear regression analysis. The data were stratified by 5-kcfs intervals (Table 22) and log transformed. Analysis showed that 67% of the variation in migration rate is accounted for by discharge (r^2=0.668, N=8, P=0.013). The same analysis was conducted for wild steelhead trout that were PIT-tagged at the Clearwater River trap and interrogated at Little Goose Dam. Analysis described a strong correlation between migration rate and discharge (r^2=0.937, N=8, P<0.001). In all instances, where sufficient data were available, the linear regression analysis detected a significant relation between migration rate through Lower Granite and Little Goose reservoirs and discharge. Only the data set for chinook salmon released at the Snake River trap was insufficient to conduct this analysis.

Table 18. PIT-tagged wild steelhead interrogations at Lower Granite, Little Goose, and McNary dams from the Snake River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
4/17	17	10	58.8	3	17.6	0	0.0	13	76.5
4/18	41	24	58.5	5	12.2	0	0.0	29	70.7
4/19	52	37	71.2	8	15.4	0	0.0	45	86.5
4/20	48	37	77.1	6	12.5	0	0.0	43	89.6
4/21	83	58	69.9	10	12.0	2	2.4	70	84.3
4/22	61	38	62.3	10	16.4	0	0.0	48	78.7
4/23	37	26	70.3	5	13.5	0	0.0	31	83.8
4/24	25	18	72.0	5	20.0	0	0.0	23	92.0
4/25	106	67	63.2	18	17.0	3	2.8	88	83.0
4/26	44	25	56.8	11	25.0	2	4.5	38	86.4
4/27	7	4	--	2	--	0	--	6	--
4/28	95	64	67.4	10	10.5	3	3.2	77	81.1
4/29	36	19	52.8	7	19.4	3	8.3	29	80.6
4/30	105	72	68.6	17	16.2	2	1.9	91	86.7
5/1	258	180	69.8	35	13.6	4	1.6	219	84.9
5/2	244	155	63.5	28	11.5	6	2.5	189	77.5
5/3	93	69	74.2	10	10.8	0	0.0	79	84.9
5/4	67	44	65.7	5	7.5	0	0.0	49	73.1
5/5	60	44	73.3	5	8.3	1	1.7	50	83.3
5/6	79	54	68.4	8	10.1	1	1.3	63	79.7
5/7	72	40	55.6	9	12.5	1	1.4	50	69.4
5/8	107	61	57.0	13	12.1	1	0.9	75	70.1
5/9	181	88	48.6	29	16.0	0	0.0	117	64.6
5/10	164	90	54.9	12	7.3	1	0.6	103	62.8
5/11	111	60	54.1	10	9.0	0	0.0	70	63.1
5/12	62	29	46.8	6	9.7	0	0.0	35	56.5
5/13	30	13	43.3	2	6.7	0	0.0	15	50.0
5/14	17	7	41.2	1	5.9	0	0.0	8	47.1
5/15	15	7	46.7	2	13.3	0	0.0	9	60.0
5/16	4	3	--	0	--	0	--	3	--
5/17	12	5	41.7	0	0.0	0	0.0	5	41.7
5/18	3		--	0	--	0	--	1	--
5/19	12	a	33.3	2	16.7	0	0.0	6	50.0
5/20	22	10	45.5	0	0.0	1	4.5	11	50.0
5/21	60	25	41.7	5	8.3	0	0.0	30	50.0
5/22	14	3	21.4	1	7.1	0	0.0	4	28.6
5/23	11	6	54.5	0	0.0	0	0.0	6	54.5
5/24	3	0	--	0	--	0	--	0	--
5/27	3	1	--	0	--	0	--	1	--
5/28	10	4	40.0	2	20.0	0	0.0	6	60.0
5/29	3	1	--	1	--	0	--	2	--
5/31	18	1	5.6	1	5.6	0	0.0	2	11.1
6/1	2	1	--	0	--	0	--	1	--
6/2	10	2	20.0	2	20.0	0	0.0	4	40.0
6/3	1	0	--	0	--	0	--	0	a -
6/4	2	0	--	0	--	0	--	0	--
6/5	1	0	--	0	--	0	--	0	--
6/6	1	0	--	0	--	0	--	0	--
6/8		0	--	0	--	0	--	0	--
6/11	3	0	--	0	--	0	--	0	--
6/12	4	1	--	1	--	0	--	2	--
6/15	1	0	--	0	--	0	--	0	--
6/17	4	0	--	0	--	0	--	0	--
6/18	1	0	--	0	--	0	--	0	--
6/19	1	0	--	0	--	0	--	0	--

Table 18. Continued.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
6/20	1	0	--	0	--	0	--	0	--
6/21	1	0	--	0	--	0	--	0	--
6/22	2	1	--	0	--	0	--	1	--
6/25	3	1	--	0	--	0	--	1	--
6/26	2	0	--	0	--	0	--	0	--
6/27	1	0	--	0	--	0	--	0	--
6/30	1	0	--	0	--	0	--	0	--
7/1	1	0	--	0	--	0	--	0	--
7/3	1	0	--	0	--	0	--	0	--
7/5	1	1	--	0	--	0	--	1	--
Total	2538	1511		307		31		1849	

Table 19. PIT-tagged wild eteelhead interrogations at Lower Granite, Little Goose, and McNary dams from the Clearwater River trap, 1992.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
3/21	1	0	--	0	--	1	--	1	--
3/22	1	1	--	0	--	0	--	1	--
3/23	2	0	--	1	--	0	--	1	--
3/24	2	1	--	0	--	0	--	1	--
3/27	2	1	--	0	--	0	--	1	--
3/28	2	1	--	1	--	0	--	2	--
3/29	4	2	--	1	--	0	--	3	--
3/30	2	1	--	0	--	0	--	1	--
3/31	2	2	--	0	--	0	--	2	--
4/1	8	3	--	0	--	0	--	3	--
4/2	12	8	66.7	1	8.3	1	8.3	10	83.3
4/3	19	13	68.4	0	0.0	1	5.3	14	73.7
4/4	30	16	53.3	3	10.0	1	3.3	20	66.7
4/5	53	20	37.7	7	13.2	1	1.9	28	52.8
4/6	164	63	38.4	32	19.5	5	3.0	100	61.0
4/7	94	47	50.0	15	16.0	5	5.3	67	71.3
4/8	97	38	39.2	14	14.4	5	5.2	57	58.8
4/9	30	16	53.3	2	6.7	2	6.7	20	66.7
4/10	27	11	40.7	5	18.5	0	0.0	16	59.3
4/11	154	72	46.8	35	22.7	7	4.5	114	74.0
4/12	129	76	58.9	22	17.1	2	1.6	100	77.5
4/13	52	30	57.7	9	17.3	0	0.0	39	75.0
4/14	67	33	49.3	12	17.9	4	6.0	49	73.1
4/15	54	33	61.1	6	11.1	2	3.7	41	75.9
4/16	31	17	54.8	7	22.6	2	6.5	26	83.9
4/17	7	6	--	1	--	0	--	7	--
4/18	146	73	50.0	27	18.5	8	5.5	108	74.0
4/19	539	301	55.8	101	18.7	20	3.7	422	78.3
4/20	188	99	52.7	34	18.1	8	4.3	141	75.0
4/21	91	50	54.9	12	13.2	6	6.6	68	74.7
4/22	70	35	50.0	9	12.9	1	1.4	45	64.3
4/23	17	10	58.8	3	17.6	2	11.8	15	88.2
4/24	8	2	--	4	--	1	--	7	--
4/25	16	10	62.5	1	6.2	1	6.2	12	75.0
4/26	18	10	55.6	3	16.7	0	0.0	13	72.2
4/27	13	7	53.8	0	0.0	2	15.4	9	69.2
4/28	103	56	54.4	16	15.5	2	1.9	74	71.8
4/29	203	132	65.0	25	12.3	10	4.9	167	82.3
4/30	363	230	63.4	54	14.9	10	2.8	294	81.0
5/1	40	27	67.5	5	12.5	2	5.0	34	85.0
5/3	3	1	--	2	--	0	--	3	--
5/6	3	2	--	0	--	0	--	2	--
5/18	20	9	45.0	2	10.0	0	0.0	11	55.0
5/19	10	4	--	0	--	0	--	4	--
5/20	11	7	63.6	0	0.0	0	0.0	7	63.6
5/24	8	3	--	0	--	0	--	3	--
5/25	16	5	31.2	2	12.5	0	0.0	7	43.8
5/26	11	4	36.4	1	9.1	0	0.0	5	45.5
5/27	8	0	--	1	--	0	--	1	--
5/28	4	0	--	0	--	0	a-	0	--
5/29	7	4	--	0	--	0	--	4	--
5/30	3	2	--	0	--	0	--	2	--
5/31	6	1	--	0	--	0	--	1	--
6/1	8	2	--	0	--	0	--	2	--
6/2	4	0	--	0	--	0	--	0	--

Table 19. Continued.

Date	Number tagged	Int. at Lower Granite	%	Int. at Little Goose	%	Int. at McNary	%	Total int.	Total %
6/3	3	1	--	0	--	1	--	2	--
6/4	3	0	--	0	--	0	--	0	--
6/12	7	1	--	1	--	0	--	2	--
Total	2996	1599		477		113		2189	

Table 20. Migration data, stratified by **5-kcfs** intervals, for chinook salmon from Snake and Clearwater **River** traps to Little Goose Dam, 1992.

Discharge interval	Snake River trap migration **rate** (km/d)'	Clearwater River trap migration rate (km/d)
20 - 25	--	--
25 - 30	--	--
30	--	3.70
35 - 35 40	--	4.89
40 - 45	--	5.33
45 - 50	--	8.02
50 - 55	--	8.90
55 - 60	--	5.83
60 - 65	--	6.85
65 - 70	--	9.20
70 - 75	--	9.25
75 - 80	--	--
80 - 85	--	--

[a] Not enough interrogations at Little Goose Dam to have valid data.

Table 21. Migration data, stratified by **5-kcfs** intervals, for hatchery steelhead trout from Snake and Clearwater River traps to Little Goose Dam, 1992.

Discharge interval	Snake River trap migration rate (km/d)	Clearwater River trap migration rate (km/d)
20	--	--
25 - 25 30	3.70	4.10
30 - 35	3.50	--
35 - 40		--
40 - 45	5.40	3.50
45 - 50	7.58	--
50 - 55	7.80	- -
55	11.85	10.00
60 - 60 65	9.40	11.10
65 - 70	12.50	12.80
75 - 75	17.00	12.80
80 - 85 80	- -	13.80
	--	--

Table 22. Migration data, stratified by 5-kcfs intervals, for wild steelhead trout from Snake and Clearwater River traps to Little Goose Dam, 1992.

Discharge interval	Snake River trap migration rate (km/d)	Clearwater River trap migration rate (km/d)
20		--
30 - 25 30	.. ..	--
35 - 40 35	.. ..	--
		9.83
40 - 45	7.20	12.10
50 - 50	13.40	13.16
55 - 55 60	12.50 13.65	12.40
		14.00
60 - 65	11.30	--
65 - 70	16.95	18.70
70 - 75	16.20	20.60
75 - 80	17.55	20.75
80 - 85	--	--

Age-0 Chinook Salmon Migration Rate and Interrosation Rate

In 1992, only 12 age-0 chinook salmon were PIT-tagged at the Snake River trap. Not enough data are available to perform a statistical analysis between migration rate and discharge or to calculate interrogation rate for age-0 chinook salmon in 1992.

Interrogation Rate of PIT-Tagged Fish

Cumulative interrogation rate (the number of fish with unique interrogation at Lower Granite, Little Goose, or McNary dams) for fish PIT-tagged at the Snake and Clearwater River traps in 1992 was slightly lower than interrogation rate estimates from 1991. A cumulative interrogation rate for chinook salmon tagged at the Snake River trap could not be calculated for 1992 due to the lack of information over the majority of the outmigration season. Cumulative interrogation rate for chinook salmon from the Clearwater River trap was 55.1%, which was 8.8% lower than 1991.

The cumulative interrogation rate for hatchery steelhead trout tagged at the Clearwater River trap was 35% higher than for those tagged at the Snake River trap (60.4% and 44.9%, respectively). The trend in previous years (1989, 1990, and 1991) was higher cumulative interrogation rates for hatchery steelhead caught in the Snake River trap (Table 23). By the time hatchery steelhead trout from the Snake River basin arrived at the head of Lower Granite Reservoir in 1992, flows had decreased dramatically. Because of the extremely low flows, many of the hatchery steelhead were stranded in Lower Granite Reservoir and probably residualized or died.

Wild steelhead trout tagged at the Clearwater River trap were recovered at virtually the same rate (73.1%) as the wild steelhead trout tagged at the Snake River trap (72.9%). Interrogation rate estimates for wild steelhead in 1992 did not follow the trend of previous years. In 1989, 1990, and 1991, the interrogation rate at the Snake River trap was 12.2% to 17.5% higher than at the Clearwater River trap (Table 23). At present, we do not know why wild steelhead trout tagged at the Snake River trap are recovered at a higher rate than those tagged at the Clearwater trap. One possible explanation is fish migrating out of the Clearwater River at flows greater than 30-35 kcfs are not sampled and marked because the trap can not function at such flows. It is presumed that fish migrating at flows greater than 35 kcfs survive at a higher rate and therefore are recovered at a higher rate than fish migrating at flows below 35 kcfs.

Interrogation rates to Lower Granite, Little Goose, and McNary dams for hatchery steelhead trout and wild steelhead trout tagged at the Snake River trap in 1992 were 44.9% and 72.9%, respectively. The interrogation rate for hatchery steelhead was two times greater in 1991, and the three-year (1989-1991) average was 89% higher than the 1992 interrogation rate. Wild steelhead trout were recovered at a higher rate than hatchery steelhead, but the interrogation rate was down 12.5% from 1991 and 10.2% lower than the three-year average of 81.2% (1989-1991).

Interrogation rates to Lower Granite, Little Goose, and McNary dams for chinook salmon, hatchery steelhead trout, and wild steelhead trout tagged at the Clearwater River trap in 1992 were 55.1%, 60.4%, and 73.1%, respectively. The chinook salmon interrogation rate for 1992 was 8.9% lower than that observed in 1991, and was 3% less than the three-year average of 56.8% (1989-1991). The hatchery steelhead interrogation rate in 1992 was 27.9% lower than the 83.5%

Table 23. Interrogation of PIT-tagged fish from the Snake River trap and Clear-water River trap at downstream collection facilities, 1988-1992.

Tagging site	Year	Species'	Number tagged	Number Interrogated/(%) Lower Granite	Little Goose	McNary	Totals
Snake trap	1992	CH	410	166 ([b])	83 ([b])	48 ([b])	297 ([b])
		cu	615	249 ([b])	106 ([b])	72 ([b])	427 ([b])
		Total	1025	415 ([b])	189 ([b])	120 ([b])	724 ([b])
		SH	3904	1496 (38.3)	227 (5.8)	30 (0.8)	1753 (44.9)
		SW	2538	1511 (59.5)	307 (12.1)	31 (1.2)	1849 (72.9)
Clearwater trap	1992	CH	5200	1654 (31.8)	745 (14.3)	429 (8.25)	2828 (54.4)
		cu	1461	502 (34.4)	202 (13.8)	136 (9.3)	840 (57.5)
		Total	6661	2156 (32.4)	947 (14.2)	565 (8.5)	3668 (55.1)
		SH	1567	823 (52.5)	118 (7.5)	6 (0.4)	947 (60.4)
		SW	2996	1599 (53.4)	477 (15.9)	113 (3.8)	2189 (73.1)
Snake trap	1991	CH	2131	929 (43.6)	409 (19.2)	115 (5.4)	1453 (68.2)
		SH	2577	2032 (78.9)	268 (10.4)	11 (0.4)	2311 (89.7)
		SW	3549	2266 (63.9)	625 (17.6)	66 (1.9)	2957 (83.3)
Clearwater trap	1991	CH	3943	1483 (37.6)	668 (16.9)	235 (6.0)	2386 (60.5)
		SH	1215	926 (76.2)	89 (7.3)	3 (0.3)	1018 (83.8)
		SW	727	409 (56.3)	102 (14.0)	28 (3.9)	539 (74.1)

Table 23. Continued.

Tagging site	Year	Species[a]	Number tagged	Number Interrogated/(%) Lower Granite	Little Goose	McNary	Totals
Snake trap	1990	CH	2,245	956 (42.6)	310 (13.8)	180 (8.0)	1,446 (64.4)
		SH	3,112	2,272 (73.0)	282 (9.1)	33 (1.1)	2,587 (83.1)
		SW	3,078	2,016 (65.5)	356 (11.6)	60 (2.0)	2,432 (79.0)
Clearwater trap	1990	CH	4,242	1,359 (32.0)	674 (15.9)	281 (6.6)	2,314 (54.6)
		SH	1,228	880 (71.7)	63 (5.1)	10 (0.8)	953 (77.6)
		SW	1,300	767 (59.0)	126 (9.7)	22 (1.7)	915 (70.4)
Snake trap	1989	CH	6,222	2,384 (38.3)	1,367 (22.0)	482 (7.7)	4,233 (68.0)
		SH	2,525	1,773 (70.2)	268 (10.6)	35 (1.4)	2,076 (82.2)
		SW	1,798	1,170 (65.1)	240 (13.3)	52 (2.9)	1,462 (81.3)
Clearwater trap	1989	CH	2,441	756 (31.0)	452 (18.5)	140 (5.7)	1,348 (55.2)
		SH	290	173 (59.7)	16 (5.5)	2 (0.7)	191 (65.9)
		SW	104	53 (51.0)	16 (15.4)	3 (2.9)	72 (69.2)
Snake trap	1988	CH	3,767	1,237 (32.8)	543 (14.4)	299 (7.9)	2,079 (55.2)
		SH	1,743	1,069 (61.3)	190 (10.9)	12 (0.7)	1,271 (72.9)
		SW	1,186	698 (58.9)	166 (14.0)	20 (1.7)	884 (74.5)

[a] CH = hatchery chinook, CU = chinook unknown, SH = hatchery steelhead, SW = wild steelhead.
[b] Percent interrogated not calculated due to lack of data from the majority of the outmigration season.

observed in 1991, and 20.3% lower than the three-year average of 75.8% (1989-1991). The wild steelhead trout interrogation rate (73.1%) was down slightly from the 74.1% observed in 1991, but slightly higher than the three-year average of 71.2% (1989-1991).

The interrogation rate for individual release groups decreased considerably during the later part of the 1992 migration season for all species from all traps. This drop was most dramatic for hatchery steelhead PIT-tagged at the Snake River trap. Interrogation rate at Lower Granite, Little Goose, and McNary dams for these hatchery steelhead dropped from the 80% range in April and early May, to the 30% range by the end of May, and to the low teens by early July. This corresponds to extremely poor migration conditions due to low flows beginning in mid-May and increasing in severity through the end of the season.

SUMMARY

Hatchery chinook salmon releases were up 13.4%, and hatchery steelhead trout releases were down 6.2% from 1991. There was an increase in chinook salmon production in the Salmon River drainage of about a million fish, a minor increase in the Clearwater River, and no change in the Grande Ronde River in 1992. The majority of the decrease in hatchery steelhead trout production occurred in the Salmon River drainage and the Hells Canyon release. Hatchery production of chinook salmon and steelhead trout released above Lower Granite Dam was 20,240,554 (10,926,802 chinook salmon and 9,313,752 steelhead trout) in 1992. Of these, 723,633 chinook salmon and 297,769 steelhead trout (6.6% and 3.2% of the total releases, respectively) were freeze-branded and released as 28 unique chinook salmon groups and 16 unique steelhead trout groups.

The Snake River trap was operated on the east side of the river from March 10 through July 27, and captured 1,887 age-l chinook salmon, 20 age-0 chinook salmon, 20,864 hatchery steelhead trout, and 2,691 wild steelheadtrout. Chinook salmon catch and the water year were the second lowest since operation began in 1984.

The screw trap was operated from March 10 to July 7 to collect age-0 chinook salmon. A total of 241 fish were captured, 18 of which were age-0 chinook. Trap catch was very low, presumably due to the lack of river discharge during most of the spring outmigration.

The Clearwater River trap was operated from March 13 through June 12, with 1 d down time on May 7 and 8 d from May 10-17 when the trap was out of operation due to mechanical problems. Clearwater River trap catch was 85,434 age-l chinook salmon, 7,143 hatchery steelhead trout, and 3,507 wild steelhead trout. Chinook salmon trap catch was the highest since trap operation began in 1984. Hatchery steelhead trout trap catch was slightly less than 1991 and wild steelhead trout trap catch was 2.3 times greater than the next highest year (1990).

Fish were PIT-tagged for migration rate statistics at the Snake River trap and Clearwater River trap in 1992. The number of fish PIT-tagged at the Snake River trap was 7,467 and the number of fish PIT-tagged at the Clearwater River trap was 11,224. To few chinook salmon were tagged at the Snake River trap to calculate a cumulative interrogation rate for the year.

Chinook salmon trap efficiency at the Clearwater River trap when the majority of the Dworshak NFH chinook passed was estimated to be 3.14%. Trap efficiency probably decreased as discharge increased later in the year. Clearwater River trap mean efficiency for hatchery steelhead trout in 1992 was not tested but it was 1.90% in 1990, which is significantly higher than in previous years when trap efficiencies were below 0.4%. Wide variations in trap efficiency occur due to discharge, trap location, and the degree of smoltification, species, and maybe rearing type of the fish.

PIT-tagged chinook salmon are a better method of determining migration rate through Lower Granite Reservoir than using freeze-branded groups. Statistical analysis could not detect a relation between migration rate and discharge for chinook salmon PIT-tagged at the Clearwater trap and interrogated at Lower Granite Dam: r^2=0.301, N=10, P=0.100. The inability to detect a migration rate discharge relation for Clearwater chinook salmon is probably due to the lack of data over a wide enough range of discharge (1992 discharge range = 35-80 kcfs). A significant migration rate discharge relation was detected for chinook salmon released from the Clearwater River trap and interrogated at Little Goose Dam: r^2=0.699, N=9, P=0.005.

Percent interrogation of PIT-tagged chinook salmon released from the snake River trap was not calculated for 1992 because of a lack of data over a large portion of the outmigration season. Percent interrogation of PIT-tagged chinook salmon released from the Clearwater River trap was 8.8% lower than in 1991 (1992055.1% and 1991=60.4%).

There was a very strong statistical relation between migration rate and discharge for Snake River trap PIT-tagged hatchery steelhead trout (r^2=0.844, N=10, P<0.001). PIT-tagged hatchery steelhead trout migrated about 2.1 times as fast at 100 kcfs as they did at 50 kcfs. This was considerably slower than in 1991 when fish migrated about 3 times faster at 100 kcfs than at 50 kcfs.

There was a strong relation between migration rate and discharge for Clearwater River trap PIT-tagged hatchery steelhead trout (r^2=0.796, N=11, P<0.001). PIT-tagged hatchery steelhead migrated about 2.3 times faster at 100 kcfs as they did at 50 kcfs.

The Snake River trap PIT-tag data for hatchery steelhead trout were examined over years (1988-1992) to determine if there was a significant difference in the migration rate/discharge relation among years. The analysis showed there was a significant difference among years that was attributable to 1992. When 1992 data were removed, there was no statistical difference in the migration rate/discharge relation for the remaining four years data (1988-1991). The linear regression model for the four combined years (r^2=0.909, N=49, P<0.001) was:

$$\ln\text{(migration rate)} = -4.092 + 1.531 \ln\text{(mean discharge)}$$

and the linear regression model for 1992 (r^2=0.844, N=10, P<0.001) was:

$$\ln\text{(migration rate)} = -2.208 + 1.048 \ln\text{(mean discharge)}$$

Percent interrogation at all three dams (Lower Granite, Little Goose, and McNary) of PIT-tagged hatchery steelhead trout tagged at the Snake River trap was 44.9%. This was about 50% less than in previous years. Percent interrogation at all three dams of PIT-tagged hatchery steelhead trout tagged at the Clearwater River trap was 60.4%, which was about 30% less than in 1991. The dramatic decrease in interrogations of hatchery steelhead trout from both traps is directly attributable to the extremely poor migration conditions associated with the low flows during the hatchery steelhead outmigration.

The PIT-tag has provided travel time data through Lower Granite Reservoir for wild steelhead trout. This is because of the low numbers of fish required for marking due to the high interrogation rate at Lower Granite Dam. The relation between migration rate and discharge for wild steelhead trout released from the Snake River trap was very strong (r^2=0.749, N=7, P=0.012):

$$\ln \text{(migration rate)} = -1.769 + 1.029 \ln \text{(mean discharge)}.$$

These fish migrated twice as fast through Lower Granite Reservoir at 100 kcfs as they did at 50 kcfs.

There was a very strong relation between migration rate and discharge for PIT-tagged wild steelhead trout released from the Clearwater River trap (r^2=0.922, N=9, P<0.001):

$$\ln \text{(migration rate)} = -1.211 + 0.932 \ln \text{(mean discharge)}.$$

Clearwater River wild steelhead trout migrated about twice as fast at 100 kcfs as they did at 50 kcfs.

The migration rate/discharge relations for wild steelhead trout for 1988-1992 were examined to see if there was a difference among years. There was no significant difference among years (i.e., homogenous slopes and common intercepts were accepted) for wild steelhead trout, and the data were pooled. The linear regression analysis on the pooled data detected a very strong relation between migration rate and discharge (r^2=0.845, N=56, P<0.001):

$$\ln \text{(migration rate)} = -2.048 + 1.105 \ln \text{(mean discharge)}.$$

Cumulative interrogation of PIT-tagged wild steelhead trout at the three dams (Lower Granite, Little Goose, and McNary) was 72.9% for Snake River trap fish and 73.1% for Clearwater River trap fish in 1992. Cumulative interrogation of PIT-tagged wild steelhead trout in 1992, as compared to the previous three years, was 8.3% lower for fish marked at the Snake River trap and 1.9% higher at the Clearwater River trap.

The migration rate/discharge relation for chinook salmon between the traps and Little Goose Dam was examined. Not enough data were available for chinook salmon PIT-tagged at the Snake River trap to perform the analysis. The analysis showed that 70% of the variation in migration rate for Clearwater River chinook salmon was accounted for by changes in discharge.

The migration rate/discharge relation for hatchery steelhead trout between the traps and Little Goose Dam was examined. For PIT-tagged fish from the Snake River trap and Clearwater River trap, 91% and 82%, respectively, of the variation in migration rate was accounted for by discharge.

The migration rate/discharge relation for wild steelhead trout between the traps and Little Goose Dam was examined. The analysis showed that for PIT-tagged fish from the Snake River trap and Clearwater River trap, 67% and 94%, respectively, of the variation in migration rate was accounted for by discharge.

LITERATURE CITED

Buettner, E.W. 1991. Smolt monitoring at the head of Lower Granite Reservoir and Lower Granite Dam. Report of Idaho Department of Fish and Game to Bonneville Power Administration, Project 83-323B, Portland, Oregon.

Liscom, K.L., and C. Bartlett. 1988. Radio tracking to determine steelhead trout smolt migration patterns at the Clearwater and Snake River migrant traps near Lewiston, Idaho. Report to Idaho Department of Fish and Game, Boise.

Mason, J.E. 1966. The migrant dipper: a trap for downstream migrating fish. Progressive Fish Culturist 28:96-102.

Mosteller, F., and J.W. Tukey. 1977. Data analysis and regression. Addison-Wesley Publishing, Reading, Massachusetts.

Murphy, M.L., J.F. Thedinga, S.W. Johnson, K.V. Koski, and J.M. Lorenz. In Press. Partitioning salmon smolt yield in the Situk River, Alaska to predict effects of glacial flooding. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA.

Ott, L. 1977. An introduction to statistical methods and data analysis. Duxbury Press, North Scituate, Massachusetts.

Prentice, E.F., T.A. Flagg, and S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Report of U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center to Bonneville Power Administration, Project 83-19, Portland, Oregon.

Raymond, H.L., and G.B. Collins. 1974. Techniques for appraisal of migrating juvenile anadromous fish populations in the Columbia River Basin. IN: Symposium on methodology for the survey, monitoring and appraisal of fishery resources in lakes and large rivers. Food and Agricultural Organization of the United Nations, European Inland Fisheries Advisory Commission, EIFAC/74/I/Symposium-24, Rome, Italy.

Rondorf D.W., J.W. Beeman, and J.C. Faller. In Press. Assessment of smolt condition for travel time analysis. Report of U.S. Fish and Wildlife Service to Bonneville Power Administration, Project No. 87-401, Portland, Oregon.

Steinhorst, K., B. Dennis, A. Byrne, and A. Polymenopoulos. 1988. Tools for analyzing fish travel time. Report of University of Idaho Statistical Consulting Center to Idaho Department of Fish and Game, Boise.

Zar, J.H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

DOE/BP-11631-9
November 1993
630